THE ENGINEER

JUNE 4, 1954

Iron and Steel Institute Meeting

THE annual general meeting of the Iron and Steel Institute was held in London last week. It opened on Wednesday morning with the retiring president, Mr. James Mitchell, in the chair. Mr. Mitchell briefly reviewed the council's annual report and announced that, assisted by the subscriptions made by forty-five companies to the House Fund, the Institute had been able to purchase a sixty-year lease on the premises at 4, Grosvenor Gardens, and, in addition, had put £10,000 aside to start the sinking fund. He referred also to the forthcoming meeting of the Institute in Sweden, and to a joint meeting next year with the American Society of Metals and the American Institution of Mining and Metallurgical Engineers. Those societies, Mr. Mitchell said, would meet in London with the Iron and Steel Institute for about a week early in June, 1955, and thereafter the meeting would adjourn to Germany and France. It would be the first time, he added, that a large body of members of the two American societies had arranged to come to this country. The presentation of the Institute's medals and awards followed, after which Mr. Mitchell inducted the Hon. R. G. Lyttelton to the presidential chair. Mr. Lyttelton voiced the Institute's thanks to the retiring president and proceeded to the delivery of his presidential address, which was entitled "Social Consequences of Iron and Steel." Extracts from this address are printed on another page of this issue. After the presidential address, the seventh Hatfield Memorial Lecture was given by Dr. T. P. Colclough, whose subject was "Development in the Iron and Steel Industry in Great Britain During the Last Twenty-Five Years." The meeting then proceeded with the discussion of papers. Later in the day the president announced that Mr. Will Evans, of The Steel Company of Wales, Ltd., had presented to the Institute paintings of three famous men in the iron and steel industry. They were of Mr. Winsor Richards, Mr. Edward Williams, and Mr. Menelaus. The annual dinner of the Institute was held at Grosvenor House, Park Lane on Wednesday evening of last week. It was attended by a large company of members and guests.

Opening of Coryton Refinery

ON Thursday, May 27th, Queen Elizabeth, the Queen Mother, boarded the Port of London Authority's launch, "St. Katharine," at Tower Bridge Pier, and journeyed by river to Coryton to open formally the new refinery of the Vacuum Oil Company, Ltd. The ceremony was attended by a large number of guests and employees, and Mr. J. C. Gridley, the chairman of the company, in his speech of welcome to the Queen Mother, mentioned that the company is an Anglo-American enterprise which began trading in Great Britain about seventy years ago. The new refinery, he continued, also was the outcome of the pooling of Anglo-American resources of ideas, money and material, and, he added, the refinery, which would increase the national productivity, incorporated several process units which were new to the country. Mr. Gridley said that the first phase of construction was complete, but that the refinery was planned with a view to future expansion, and then, after briefly referring to the disastrous floods of February, 1953, he invited the Queen Mother to declare the refinery open. Before unveiling a tablet commemorating the occasion, the Queen Mother emphasised the value of British and American co-operation in the industrial field and wished success to the enterprise. Mr. B. Brewster Jennings, the president of the Socony-Vacuum Oil Company Inc., thanked Her Majesty on behalf of the company and went on to say how highly integrated the oil industry was and to touch briefly upon the special techniques involved in the finding of oil, its production, transportation, and finally its refining into various products for distribution to the consumer. The widespread locations of the sources of crude oil, he stated, had brought those in the oil industry into contact with men of many countries, of widely differing customs and of language. Those circumstances, he felt, had given rise to more international thinking and had caused people of widely different philosophies to work together to produce oil.

Paddington Station Centenary

ON Saturday last a tablet was unveiled on Platform 1 at Paddington Station to mark the centenary of this terminus. The tablet was unveiled by Mr. A. S. Quartermaine, a former chief engineer of the Great Western Railway and of the Western Region. The tablet of polished Purbeck stone is fixed to one of the original cast iron columns to the right of the entrance to the new passenger enquiry office and on it the dates 1854 and 1954 are inscribed, and an inset bronze plaque in low relief depicts the head and shoulders of Isambard Kingdom Brunel, who designed and built the station. Plans for the new station were authorised in 1851, sixteen years after the opening of the first section of the G.W.R., and for this work Brunel had Matthew Digby Wyatt as a collaborator on the architectural side. The departure side of the station was brought into use on January 16, 1854, and the arrival platforms were opened on May 29th. The total cost of the new station was over £650,000. The interior of the main part was 700ft long and 238ft wide, divided by columns giving three spans and crossed by transepts to permit of the use of large traversing frames. Its roof consisted of wrought iron arched ribs with glass panels, the design of which Brunel adapted from Paxton's Crystal Palace. Four platforms were provided and ten lines of 7ft broad gauge track. It is a testimony to Brunel's foresight that his station of 1854, with the addition of one platform in 1878 and two more, in place of carriage sidings, in 1884 and 1893, all under the original roof, sufficed to meet all traffic requirements for more than fifty years. Work on three new platforms with a new roof span, of 109ft, on the arrival side was started in 1909 and completed early in 1916. Further reconstruction work of importance at the station included the provision of a new parcels depot, platform extensions and the development and construction of a new roof over the circulating area, and the remodelling of Bishop's Road Station. All this work was completed by the end of 1933.

Memorandum on Air Pollution

THE National Smoke Abatement Society has submitted to the Committee on Air Pollution a memorandum setting out some proposals on which it believes action should be taken. The memorandum emphasises that the case for smoke prevention is of such importance that it is necessary for the problem to be dealt with in its own right and at the highest levels of priority in all questions of fuel utilisation and development. The Society considers, for example, that loans for new fuel burning plant should be granted not only for the promotion of fuel economy, but also for the prevention of air pollution, including smoke, grit and noxious gases. The new National Industrial Fuel Efficiency Service the memorandum says, should similarly be required to assist in solving air pollution as well as fuel efficiency problems. The memorandum also urges that further research, or the encouragement and financial support for research by industry, on outstanding pollution problems is necessary and should be initiated by the Government. Among the important problems, the Society claims, are those of the removal of sulphur oxides and of grit and dust from flue gases; those arising in the iron and steel industries, the clay industries, coke ovens, cement manufacture and lime burning; chemical pollutants and road vehicle exhausts, and the further development of solid smokeless fuels and of domestic appliances. Furthermore, it is stated, it is necessary to ensure that the results of research are at once made generally known, and that their application is promoted with as little delay as possible. The Society considers that the importance of this is demonstrated by the remarkable differences to be found, in respect of air pollution, between the best and worst installations in many industries. The National Smoke Abatement Society goes on to say in its memorandum that a great deal of pollution from industrial sources could be prevented by the greater interest, co-operation and pooling of knowledge in industry itself, and it considers too that the trade unions should co-operate more closely in activities for the prevention of air pollution.

Employment of Older Engineers

THE Engineers' Guild has now formed a panel to which older members, who are unable to find suitable employment through the normal channels, can go for assistance and advice. Members seeking help from this panel should write to the assistant secretary of the Guild (at 78, Buckingham Gate, London, S.W.1), when they will be asked to complete a form giving the necessary particulars about themselves. Arrangements will then be made for them to meet one or other of the members of the panel. After interview and advice, the panel will endeavour to locate "voids" rather than "vacancies" where applicants' abilities could be usefully employed. Those who may be interested in this matter are asked to bear in mind that applications cannot normally be considered from people below the age of fifty-five, that the scheme is at present restricted to members of the Guild, and that in the initial stages of the scheme it may be difficult to arrange interviews outside London.

Institution of Water Engineers

THE summer meeting of the Institution of Water Engineers was this year held at Plymouth, on Wednesday, May 26th. The presidential address was delivered by Mr. Norman G. Elliot and two papers were presented for discussion, namely, "The River Tavy Scheme," by Mr. P. J. Stuckey, and "Farm Water Supplies in the Mid-Cheshire Area," by Mr. E. R. Griffiths. During the course of his presidential address Mr. Elliot spoke of the flourishing state of the Institution, whose corporate members numbered 1223, he noted. He then went on to give his views on some of the changing aspects of the modern world, particularly those relating to the organisation of industry. In industry, power was increasingly leaving the hands of the practical men, he said, and was falling into the hands of those, who, like the schoolmen of the Middle Ages, dealt entirely with abstract ideas and thought "legalistically." The main factor, he thought, was the ever growing complexity of business organisation, so that the real point of business became obscured under the overwhelming detail of its management. Mr. Elliot touched upon the nationalisation of the water industry; in his view the question of ownership had ceased to matter very much. The water industry had a great record of public service, he noted, when nearly every other business had been thinking in terms of profit, and he firmly believed that this tradition would be extended into the future.

Some Recent Swiss Hydro-Electric Schemes

No. VII—(*Continued from page 772, May 28th*)

An interesting constructional work, involving a barrage, a power station and a lock, is at present in progress on the River Rhine at Birsfelden, close to the city of Basel. The completed scheme will have a gross production of energy of about 440 million kWh each year, from four 22·5MW Kaplan turbo-alternator sets operating under a head of 6·5m to 7m under average flow conditions. The navigation lock will be 180m long and 12m wide.

A CONSTRUCTIONAL work in a large, swift-flowing river such as the Rhine, always has particular interest for the civil engineer. It would be expected, therefore, that the Birsfelden project, which involves such construction, would incorporate some interesting civil engineering methods, and in fact the building of the barrage and power station in the river bed has been based on some difficult river works. As with the Wildegg-Brugg scheme described last week, the Birsfelden project has also been influenced by existing developments on the project site. The plan, Fig. 32, shows the various works of the scheme. It will be seen that there is a barrage across the Rhine, with five 27m bays, and with a power station on the left bank side of the river. There is then a lock on the left bank with entry canals above and below it. From the constructional point of view alone, it would have been more favourable to have sited the power station on the right bank, but the area there is a built-up one, whereas the left bank works are being constructed on the edge of an airfield which is no longer used and is to be redeveloped. The German frontier runs along the Rhine as far as Grenzacherhorn, as marked on Fig. 32. Therefore, 40 per cent of the concession is German ; an agreement has been reached, however, whereby all the power from Birsfelden will be consumed in Switzerland, and the amount due to Germany made good from another jointly-owned power station, Albbruck-Dogern, further up the Rhine. Although all the power from Birsfelden will be consumed in Switzerland, however, it was stipulated that 40 per cent of the work should be carried out by German contractors. The power station is thus being built by two German firms and a Swiss firm, the barrage by three Swiss firms and a German firm, and the lock by a Swiss and a German contractor.

At Birsfelden, the flow of the Rhine averages about 1000 cumecs, with a low-water flow of 500 cumecs or less for about twenty-five days in the winter of an average year. The power station is designed for a rated flow of 1200 to 1300 cumecs, which is normally maintained for about 123 days in the year. The spring and summer floods may be heavy, the ten-year flood being 3000 cumecs. The head available for power generation will decrease to 4·08m with a flow of 3000 cumecs, and will increase to 8·08m for a flow of 500 cumecs ; for the average flow of 1000 up to 1300 cumecs, however, the head is between 7m and 6·5m.

There are to be four Kaplan turbo-alternator sets in the power station, each of 22·5MW. The upstream level of the intake canal of Kembs power station, the first of the Rhine power stations on the French side of the border, extends up to the Eisenbahn Bridge, and the tail-race level of Birsfelden is 30cm above that level, the difference being due to the confluence of the River Birs, which flows into the Rhine on the left bank just above the bridge. The rated flow is, however, higher at Birsfelden (1200 to 1300 as against 1000 cumecs) than at the French power stations of Kembs and Ottmarsheim.*

Upstream from Birsfelden, the effect of the new barrage will be felt at the Augst-Wyhlen power station, a hydro-electric installation which has been in operation since 1912. The available head at Augst-Wyhlen will be reduced by the new works, and its output lowered. The loss thus caused will be made good with power from Birsfelden. The gross production of energy at the new station will be 440 million kWh a year and of this amount 78,000,000kWh will be needed to compensate the losses at Augst-Wyhlen, giving a net production of 362 million kWh.

The lock and the navigation canal involve a substantial volume of excavation—about 220,000 cubic metres—and the gravity walls of the lock will require a total of 47,000 cubic metres of concrete. Aggregates are obtained from the excavation and there is an installation of plant for washing, crushing and screening the aggregate with silos for storing the graded aggregates, and a concrete tower for batching and mixing the concrete, with three 1-cubic-yard concrete mixers. The plant has a capacity of some 170 cubic metres of concrete per hour and is very similar to the plants already described in this series of articles for the various dams of the high head schemes.

The lock has a length of 180m and a width of 12m. It is founded partly on sandstone and partly on gravel. The maximum difference in level across the lock, corresponding to the maximum gross head of the scheme, will normally be about 7m. It will be closed at the upstream end by a lifting gate and at the downstream by a pair of mitre gates. There will be no culverts for filling and emptying and water will pass through sluice valves in the gates. At the formation level of the invert of the lock a stratum of gypsum was encountered, which would have had a deleterious effect upon normal Portland cement concrete. A blinding layer of concrete, with 300kg of cement per cubic metre and a " Frioplast " additive (an air-entraining agent) was therefore placed first, and then a bituminous sealing layer was constructed above it, with the normal concrete mix of the lock placed inside the bituminous seal.

Spoil from the excavation of the lock and navigation canal is being transported to a riverside site about 4 miles upstream, where it is being used for filling in gravel pits and reclamation in the construction of a quay and other facilities.

There is sufficient space at the site to allow the construction of a second lock, should it be required in the future. The lock at present under construction is of generous size for the present traffic requirements (about 1,000,000 tons of shipping a year), and it will accommodate two normal Rhine barges and a tug. The canal above and below it has also been made of ample size to allow manœuvring of tugs and barges as they moor and travel through the lock. The low-level canal on the tail-race side is 450m long and 60m to 80m in width. The upper canal is 250m long and 54m wide. It will take seven to ten minutes for vessels to descend through the lock and twenty-one to twenty-five minutes to ascend (thirty-two to thirty-five minutes for the full cycle).

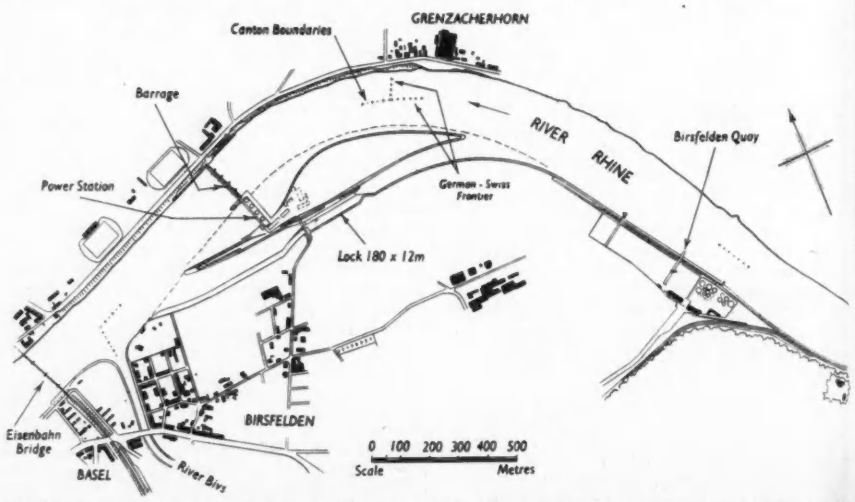

Fig. 32—The Birsfelden scheme which provides for a 90MW power station and a navigation lock 180m by 12m

The layout of the scheme, as described above, was determined after extensive tests with hydraulic models, during the course of which several alternative layouts were investigated.

River Works for the Barrage and Power Station

Steel sheet piled cofferdams and compressed air caissons have both been employed for the construction of the foundations of the barrage and the power station in the bed of the Rhine. The principal requirement for these works was that at no time should navigation on the Rhine be interrupted ; the design of the scheme was therefore evolved with provision for temporary works, which left at least one of the 27m bays of the barrage free at all times. Construction is now well advanced ; the illustrations Figs. 33 and 34 herewith illustrate the earlier stages of the work.

The first stage of the work comprised the construction of a cofferdam to enclose the

* See THE ENGINEER, June 6 and 13, 1952.

area of the long pier between the barrage and power station, and the construction of that pier inside the cofferdam. The footings of the four remaining river piers of the barrage were then built with caissons. The illustration of the barrage under construction (Fig. 33) shows that it includes two service bridges on the upstream and downstream sides respectively. The constructional method involved first the sinking of two small caissons at each pier, each one corresponding to the position of one of the service bridges. With these two small caissons sunk in position the position of the piers was then defined. Reinforced concrete towers were built up from each of the caissons and the two service bridges completed by the positioning of steel plate girder spans. A gantry spanning between the two bridges, and able to travel along them, was then erected and used throughout the constructional work for the construction of the main piers and also the sluice gates.

A large caisson, corresponding to the size of the pier itself, was then sunk between each pair of small caissons. All the caissons were of reinforced concrete and were sunk into the moraine forming the river bed to an average depth of 8m, and a maximum depth of 9m below the river bed on to a substratum of sandstone. The maximum working pressure inside the caissons was 1·5 atmospheres. The large caisson of each pier was 6·30m by 25·20m in size. The pier superstructure was built on it in reinforced concrete.

When the piers of the barrage were completed the sill was built by sealing off each bay in turn with cofferdams and dewatering (Fig. 33). Gravity cofferdams were employed with two rows of steel sheet piles about 5m apart filled in between with gravel and sand. The river bed was then excavated inside the cover of the cofferdams to a depth of about 3m to 4m and the sill constructed of concrete. The gate sill was positioned sufficiently accurately for the gates to be built later on the superstructure, after the cofferdams had been removed, and then lowered into position.

Whilst this work was in progress on the barrage the power station site was enclosed by a cofferdam, extending from the central pier already constructed, well clear of the power station on the upstream side, to allow the construction of a concrete head-race and the positioning of constructional plant. Downstream it extended far enough to seal off the tail-race and the entrance of the navigation canal. The total length of this cofferdam wall is 570m; upstream of the power station it consists of a single row of heavy steel sheet piles, propped by raking struts and with a mass concrete backing at the bottom of the piles extending back and covering the feet of the struts (Fig. 34). Downstream it consists of a gravity section, similar to the cofferdams of the barrage. All the substructure works of the power station are being constructed, in the dry, inside this cofferdam.

The various cofferdams were designed to withstand a river flow of 3300 cumecs. In fact, flows in excess of that amount were experienced last year, when the last of the cofferdams for the barrage sill was in position and the power station cofferdam was in use. The floods of last summer reached a peak, on this part of the Rhine, on June 26th, when a flow of over 4000 cumecs was maintained, the highest flow recorded since 1910. The two cofferdams were both overtopped, and a breach was caused in the large cofferdam where it joined the river bank at its downstream end. The scaffolding, shuttering and building plant and huts inside the big cofferdam were all submerged, but did not suffer much damage, and work was continued above water level while the flood lasted. In constructing river works of this nature it is often found uneconomical to proportion cofferdams to take the largest known flood, and such was the case at Birsfelden. When the peak of the flood had passed the one breach was repaired and the cofferdams were pumped out. The permanent works were undamaged and no appreciable delay was caused in their progress.

The power station, like the piers of the barrage, is founded on sandstone. It is a reinforced concrete structure. The turbine inlets are of large size, each about 37m across, for the flow is large (300 cumecs for each machine) and the head relatively low. Thus extensive reinforced concrete works have been entailed in the construction of the turbine inlets and draught tubes. The head-race is formed from an area partly excavated from the left bank of the river, as the plan shows.

(To be continued)

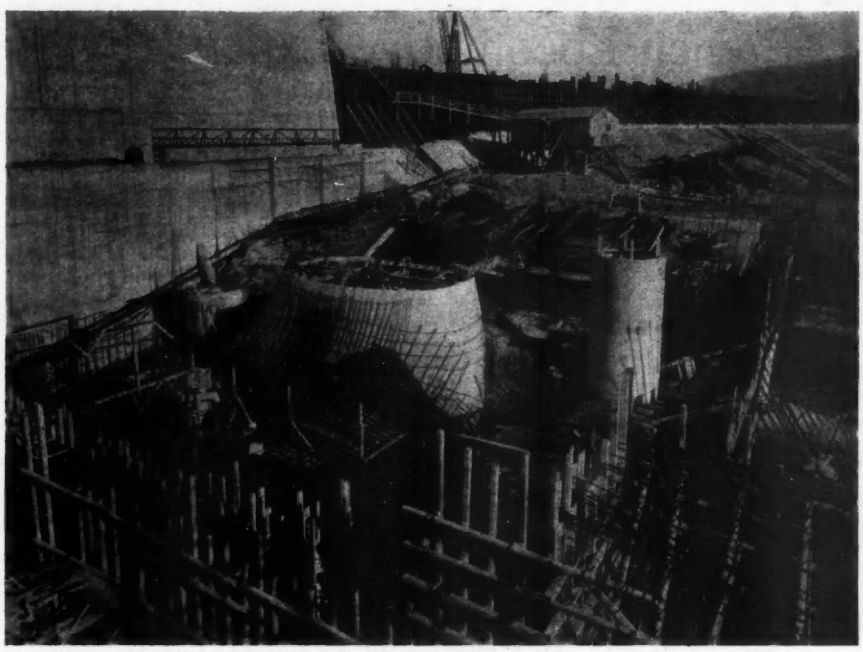

Fig. 34—Construction of power station substructure, showing draft tube shuttering and steel sheet piling of large cofferdam in the background

Fig. 33—Construction of river works showing large power station cofferdam and smaller one for construction of the barrage sill. The main caisson of the second barrage pier is in position between the service bridges

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ONE-YEAR COURSE IN CONCRETE PRACTICE.—The City and Guilds of London Institute has prepared a one-year part-time course in concrete practice which is intended to provide a qualification for supervisors and potential supervisors engaged in concrete work, denoting ability to carry out efficiently the processes connected with the production, placing and finishing of concrete. The course is planned on a basis of twenty-four lectures, i.e., one two-hour evening lecture per week, and the scheme will operate from the commencement of the session 1954–55. The first examination, which will consist of a written paper and an oral test, will be held in May, 1955, and certificates will be awarded to successful candidates. Full particulars of the course can be obtained from the City and Guilds of London Institute, Department of Technology, 31, Brechin Place, South Kensington, London, S.W.7, price 6d.

French Locomotive Experiences

By EDWARD H. LIVESAY

(*Continued from page 775, May 28th*)

No. XI—STRASBOURG/PARIS: 4-6-2 AND 4-8-2 FOUR-CYLINDER COMPOUND LOCOMOTIVES

THE return to Paris the following day was made on two engines, the first, as far as Nancy, No. 231-K79 (Figs. 53 and 54), a four-cylinder compound "Pacific," and the second, from Nancy onward, No. 241–A38 (Figs. 55 and 57), also a four-cylinder compound, of 4–8–2 "Mountain" type. The chief dimensions of the former are :

Cylinders :	
H.P. (outside)	17·6in by 26in
L.P. (inside)	26in by 26in
Wheels :	
Bogie, diameter	3ft 4in
Driving, diameter	6ft 6in
Trailing, diameter	4ft 6in
Boiler	5ft 6in by 19ft 10in
Pressure	235 lb
Heating surface :	
Firebox	169 square feet
Tubes (inside)	2058 square feet
Superheater	737 square feet
Total	2964 square feet
Grate area	45·9 square feet
Valve gear	Walschaerts, piston, direct to h.p. valves, thence by rocking levers to l.p.
Weights :	
Bogie	26 tons
Driving wheels	55·5 tons
Trailing truck	17·5 tons
Total	99 tons

Fittings include A.C.F.I. feed-heater, double blast pipe and chimney, mechanical lubricators, Flaman recorder, &c.

These engines were first built some thirty years ago and rebuilt in 1938, No. K79 being one of the last of the class.

No. 231–K79, with fourteen coaches weighing some 500 tons gross, left Strasbourg at 11.22 a.m., 7 min late, due to the tardy arrival of a connecting train from Germany, Monsieur Calmus again accompanying me in the cab. The crew, Basle men, mécanicien Jeunemaître and chauffeur Hugenôt, at once made me welcome, my own overtures being accepted at face value with the help of a box of cigars. Hugenôt, a laughing 6ft 6in giant of Herculean build, promptly indicated with vivid gestures and the French equivalent of "Sit ye doon, mate !" that he wanted me to occupy his home-made spring seat, a novelty that had already caught my eye, and though it was really over early in the game to begin sitting down, I did so, being too scared of him to refuse. It would have been both useless and dangerous to do so, anyhow, as he could have forced me into it, or thrown me out of the cab with one hand, and by this time we were travelling fast. Moreover, on this engine the Flaman recorder was on the fireman's side, right beside me, and the firing was by hand, which meant that the seat's rightful occupant and constructor would not need it until things had shaken down—or I had fallen off. The firedoor was of the sensible inward-swinging type I have mentioned before ; it seems to me to have many virtues and no vices. The brakes were tested as usual when the speed had reached 60 m.p.h. or so ; the look-ahead was good, thanks to large windows placed diagonally, and a deflector strip was in position at the front edge of the side window. At Brumath, on the rising gradient that extends practically without a break for 27 miles, the Flaman said 110km, at which the riding was noted as "good—motion all in perfect shape." Passing Hochfelden, very slightly rising, 115km was noted, with steam nearly up to 235 lb ; this engine had an A.C.F.I. feed heater, and one live steam injector. On this line, when a distant signal was "off," a bell rang ; when one was "on," a horn sounded. The Saverne stop was made at 11.50 a.m., 27 miles in 28 min, two-thirds of the distance on a rising gradient, good going with 500 tons.

Twelve miles beyond Saverne, just after Arzwiller, marked the summit of the long climb from Strasbourg ; this is well inside the Vosges country, where there were several tunnels, one 2 miles long, as mentioned earlier. Near the mouth of these a board "S" is placed, signifying "Whistle," acetylene lighted after dark, a good example of thoroughness where safety is concerned. The Rhine-Marne Canal, alongside at one point, was noted, dry for cleaning ; the second stop, at Sarrebourg, was made 12.13 p.m., O.T.; 17 miles in 20 min; climbing, curvature, tunnels and restrictions have to be paid for in speed. Following Sarrebourg came another long climb to Réchicourt, after which it would be all downhill and level to Nancy. Hugenôt's spring seat was very effective ; there was even a footrest combined with it, and I regret not having made a sketch of the whole ingenious arrangement, which he was very proud of, emphasising that it was his idea, and the S.N.C.F. had nothing to do with it. I liked this merry, grimy Hercules, but would rather he were friend than enemy ; without doubt he was the former ; the little cigars had helped. He was kept fairly busy, but I did not have to worry about him ; he was not overworked, nor was "his brow sicklied o'er with the pale cast of thought" of how to keep steam up. It always was up ; my notes say, "no need to record it—fireman did not have to extend himself—Augean stables would be well within *his* powers !" The coal looked decidedly better than usual, which may have accounted for the absence of briquettes ; it probably came from the Sarre.

At Heming, very likely on the Alsace-France border, Gallic nomenclature beginning here, we switched from right to left track by a fly-over ; at Avricourt, just beyond the peak of the climb from Sarrebourg, on down grade, the Flaman said 75 m.p.h., the highest noted yet and, I imagine, the line limitation. At this speed the riding was excellent, the spring seat making the trip unusually comfortable, but when I wanted to stand up to test things my action was invariably misunderstood by the friendly giant with the shovel, who would not allow it, and he was still too impressive to resist. It was getting a bit monotonous—I had been sitting all the way from Strasbourg ! At Emberménil, well down the declivity, the speed was still 75 m.p.h., so evidently this was the limit. At 75 m.p.h., almost drifting, the high-pressure steam chest gauge registered 4 hpz, and the low-pressure 0/1, so the low-pressure cylinders were practically out of commission. Both valve gears were controlled by one wheel ; the exhaust nozzle (Lemaître system) was adjustable by a small wheel alongside the former, and the cut-off at this speed was 45 per cent.

Lunéville was the third stop, at 12.45 p.m., 2 min early ; 29 miles from Sarrebourg in 29 min, half climbing and half descending. Away again at 12.49 p.m., the speed quickly rose on the still falling gradient to 70 m.p.h. until checked to 10 m.p.h. for a bridge restriction at Dombasle, halfway to Nancy.

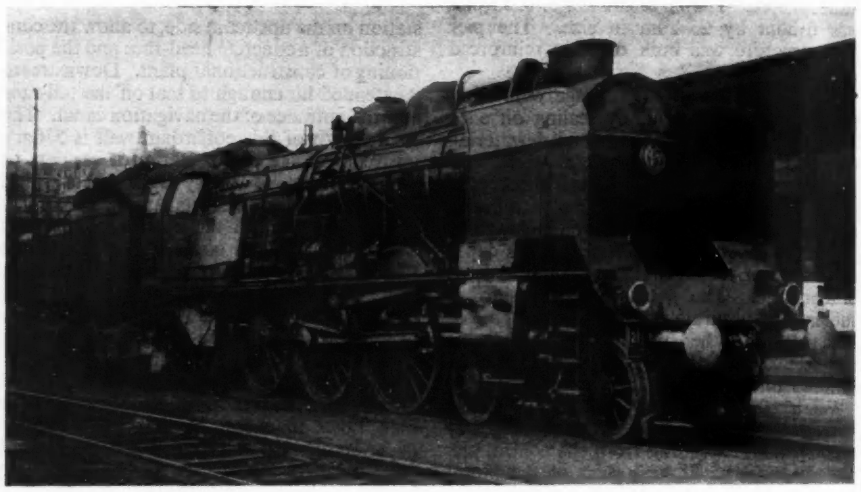


Fig. 53—Four-cylinder compound 4-6-2 "K" class express locomotive

This fairly high-speed run through lovely country was very pleasant ; the cab was cooler than yesterday, as also was the weather ; the engine was behaving splendidly, everyone in the cab was excellent company—in fact, there was not a single fly in the ointment. The notebook brings it all back to me ; . . . "thoroughly enjoying this trip—but wish Hercules would let me stand up !" On this engine the A.C.F.I. lubricator was on the driver's side of the cab ; its handle, moving up and down, gives visual indication of the rate of operation ; it had been working all the time, and I do not think the l.s. injector had been called upon at all. Another entry : "Everybody dirty—hand-fired coal-burner—self very dirty—another reason for happiness !" It lasted right into Nancy, where No. 231-K79 came to a stand at 1.17 p.m., was uncoupled and went away to the shed. According to the record, the 21 miles from Lunéville had taken 26 min, with one check down to 10 m.p.h. *en route*, which seems so unusually slow that I do not understand it. Anyway, the 94 miles from Strasbourg had been covered in 115 min, with three stops occupying 11 min ; deducting

these, the running time had been 104 min, making the average speed 54·3 m.p.h. The route had been fairly heavy, and the maximum speed allowed 75 m.p.h., so the performance was better than it sounds. Needless to say, the engine was in perfect shape and had behaved perfectly, too. So had the crew!

No. 241–A38 backed on here—an impressive machine, as seen from Fig. 57, the picture being taken before leaving. Its proportions can be judged from the individual beside it, who is 5ft 11in in height. The chief dimensions are :—

Cylinders :	
H.P. (outside)	17in by 28·53in
L.P. (outside)	26·4in by 28·35in
Piston valves, Walschearts gear	
Driving wheels, diameter	6ft 6in
Steam pressure	290 lb
Boiler, length between tube-plates	19ft 8in
Heating surface :	
Evaporative	2411 square feet
Superheater, type Est.	753 square feet
Firebox, Belpaire wide, with combustion chamber :	
Grate area	47·6 square feet
Lemaître trefoil blast pipe	
Wheelbase :	
Coupled	20ft 2in
Total engine	43ft 1in
Adhesion weight	77·5 tons
Maximum axle load	19·65 tons
Engine weight	121·6 tons
Maximum drawbar horse power at 62 m.p.h.	2800

This class of engine is unusual, according to S.N.C.F. practice, in being fitted with a Worthington feed-water heater and pump, two l.s. injectors taking further care of boiler supply. The trailing truck, as can be seen from the picture, has the springs outside the frame, and inside axleboxes, the weight being taken by a heavy cross-beam extending between the springs and passing through slots in the frame, which can also be seen. This arrangement had a repercussion which comes into the account of the run later.*

No. 241–038, with a load of about 750 tons gross, enginemen Jeunemaître and Hugenôt still in charge, and Monsieur Calmus looking after me, as before, pulled out of Nancy at 1.29 p.m. ; with this heavy train there was not a trace of slipping on the level track. The cab was large and well-roofed, with wind-deflectors at the side windows, and the engine being hand-fired on a big grate, at first I was ready to sympathise with Hugenôt, whose mighty thews and sinews would have to be brought into full play on this job, it seemed probable. Another example of his spring seat was in use on this engine, though possibly an earlier model, not quite so luxurious as the other, and again he insisted on me taking it ; I meekly did so, discretion still being the better part of valour. The speed soon rose to 70/75 m.p.h., the riding being beautiful, even better than that of the 4–6–2, though the springing was not equalised ; the motion was just as perfect—not a sound from anything—flawless. How do they do it in France, and we so seldom in England ? My spirits, already high, rose still higher—this was going to be a splendid run, without any doubt—engine, speed, load, crew, weather, country—all would ensure it. The Moselle was flowing peacefully alongside on the right, then crossing to the left as, together with it, the line wound through wooded hills basking under the summer sun. The cab proving a trifle warm and I showing signs of it, Hugenôt at once wrenched the front window open, letting the breeze blow through. I had tried to open it myself, only it stuck fast ; but one pull by Hercules was enough—it opened—"Merci!"

The train swept through Fontenoy ; the name seems to arouse some historical memory, like many places with which I had brief encounter in France ; there is an American airfield there at present, less interesting. Toul was passed at speed, 1.55 p.m. ; it is 1 in 200 up on the approach and the 20 miles from Nancy had taken 26 min. Here I began to notice a slight knock under the cab floor, evidently proceeding from the trailing truck, and seeming to coincide with rail-joints ; I drew Calmus's attention to it. He did not think it was the truck ; he suggested possibly the ballast, freshly laid, had not consolidated under the twin sleepers used in France at joints. Unconvinced, I returned to the charge again later—"Surely there is some little thing the matter with the truck, even if the ballast were initially responsible ?" "Perhaps,"

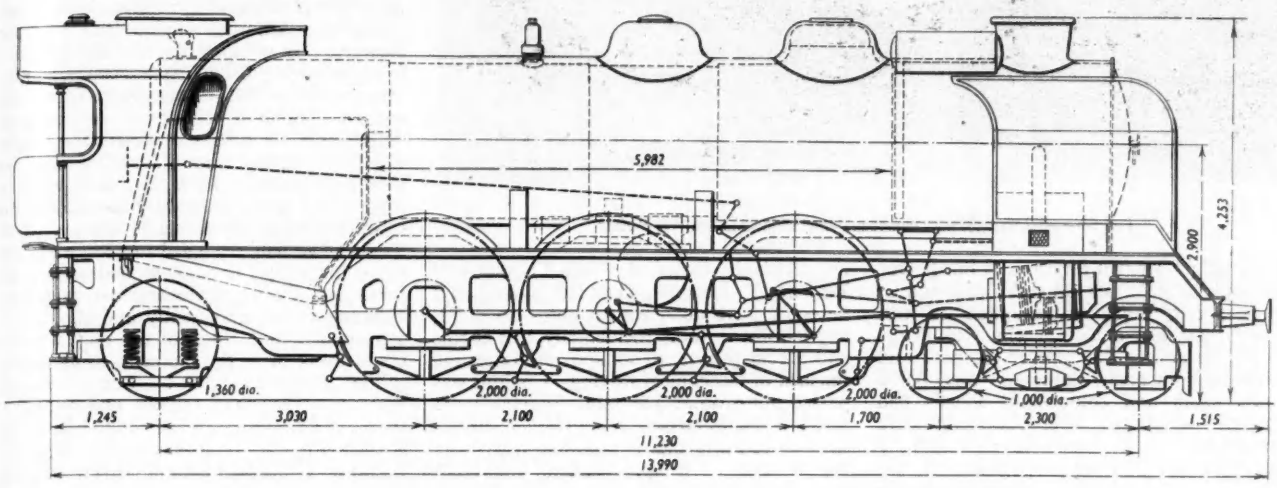


Fig. 54—Leading dimensions of four-cylinder compound 4–6–2 "K" class express locomotive

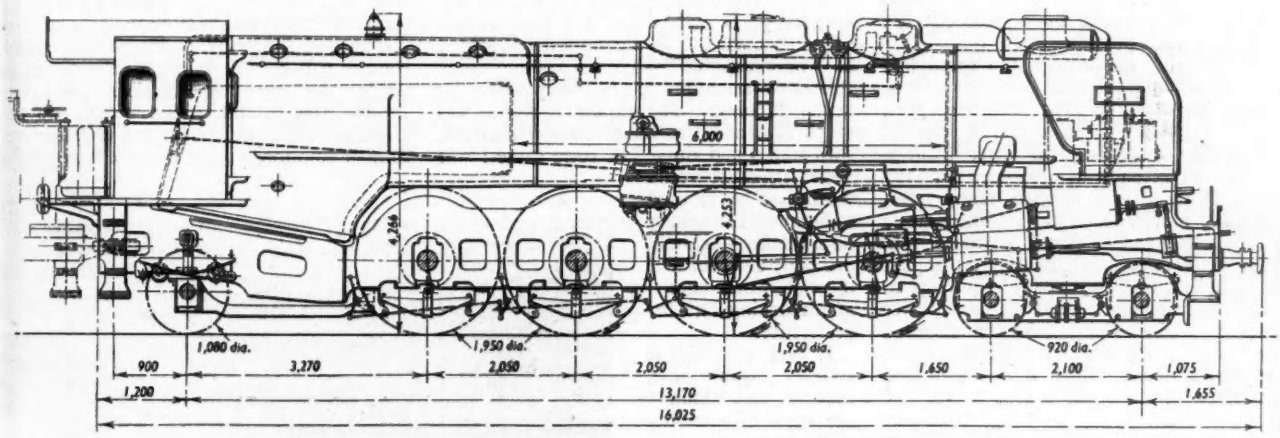


Fig. 55—Leading dimensions of four-cylinder 4–8–2 "Mountain" class express locomotive

* Since this article was written the following additional details have become available. This class, of which there are eighteen examples, was built in 1918, and rebuilt with modifications in 1934. No. 241–A38, on which I rode, is the last but two of the series. As the drawing shows, it is not fitted with equalisers, though some of the class are, but the riding was perfect, which bears out the opinion previously advanced by the writer that equalisers are not necessary where the track is good. In Britain, of course, they are never used—in North America they are always fitted.

There are thirty large tubes, 5½in in diameter, and 130 small tubes, 2 ¼in ; they are 19ft 6in in length. The firebox has a large combustion chamber and provides 283 square feet of heating surface. The boiler is 5ft 10in in diameter at the largest ring. The bogie wheels are 3ft 1in diameter and carry 26·8 tons ; the drivers are 6ft 6in, carrying 77·4 tons, the trailing truck wheels are 3ft 7in and carry 17·4 tons. The ratio between h.p. and l.p. cylinders is 1 : 2·4, and the h.p. cylinders are 89·67in apart, the l.p. 28in. The piston valves are : h.p., 10in diameter, and l.p., 12in. I have no figures of their respective travel. The tender is of the standard S.N.C.F. type, weighing about 70 tons and carrying 9 tons of coal and 7700 gallons of water.

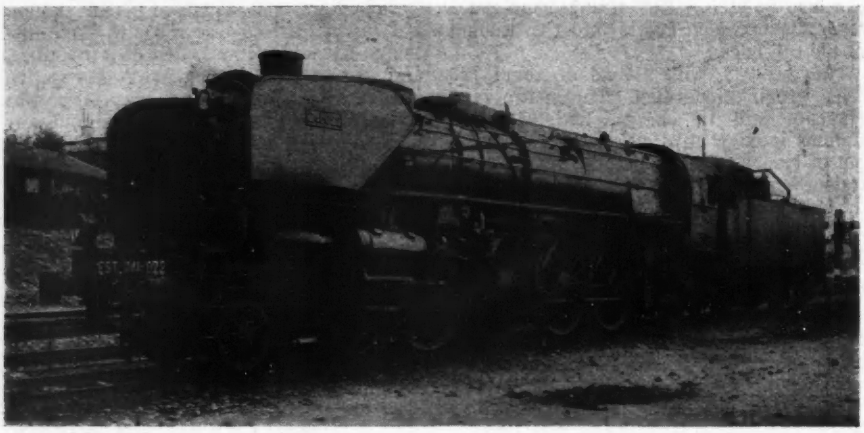


Fig. 56—4-8-2 four-cylinder compound express locomotive, "K" class

he agreed; "we will get down at Bar le Duc and look at it." Several miles followed at lower speed, 50/55 m.p.h., due to this fresh ballast and a lengthy climb to Pagny sur Meuse at 1 in 285; over the peak and descending through Sarcy it was 65/70 m.p.h. again and colour-light signals had replaced semaphore. Near Commercy there was a signal check down to 15 m.p.h., a very rare thing in my experience on the S.N.C.F.; accelerating, and on the 6 mile 1 in 125 climb to Loxéville, the h.p. steam chests showed 250 lb, and the l.p. about 45 lb, on 35/45 per cent cut-off, respectively; boiler pressure, a possible 290 lb, was slightly down. Nearing the summit the speed had fallen to 40 m.p.h.—the load, it will be remembered, was 750 tons. Over the peak the speed quickly rose to 65/70 m.p.h.; track-laying was going on here, from a machine not actually in evidence, but long lengths of rails, with sleepers ready fixed, were lying alongside. And so into Bar le Duc, to a stop at 2.43 p.m.; 61 miles from Nancy in 74 min, approximately 50 m.p.h., this including the very heavy climb up to Loxéville; Hercules earned his money over that piece! Here Calmus, Jeunemaître and I got down to examine the trailing truck—there *was* a defect, which it appeared had been noted at the shed, but as it was not serious, and called for "hoisting," the repair had been postponed. The cross-beam transferring the weight from axleboxes to springs, crossing the engine under the footplate and passing through the slots seen in the picture, was hitting the frame slightly when a rail-joint "gave" too much; this was the only defect noticeable about this splendid machine.

We left Bar le Duc at 2.58 p.m., with the 157½-mile non-stop run to Paris ahead; live steam was, of course, briefly admitted to the l.p. cylinders at starting. The engine can be worked as a simple, and I really should have had occasion to yearn over Hercules had this been necessary—a 48 square foot grate and 750 tons! Still, I am sure he could have managed it—no mechanical stoker is needed in *his* cab! The afternoon had turned hot, and so had the cab; a canvas bucket hung outside acting as cooler for bottles of liquorice water was often called on. There was frequent spraying of the cab floor; in fact, of the entire cab and its occupants—everything got it, but nobody complained—it was welcome. A jet of water spraying the bunker from the trailing edge of the cab roof, a novelty to me, that, too, added its quota of moisture to the atmosphere, and looked so tempting I inquired if there was any objection to my getting into the bunker and letting it spray me as well, but the idea was politely negatived—it seemed this was "not done." Why not? Hugenôt, stout lad, looked as if he could have done with a bath—so did I, and felt like it, too. Incidentally, this engine had a coal pusher, to some extent offsetting the lack of mechanical stoking. Chalons was passed non-stop at 3.49 p.m., 51 miles in 51 min; it was to be easy going from here right the way to Paris and, in fact, had been from Bar le Duc. The l.p. cylinders would not have much to do; for instance, near Vitry le François, running slightly down at 70 to 75 m.p.h., the h.p. gauge read 8 hpz and the l.p. between ½ hpz and 1 hpz. The firedoor was left parly open and all the motion was logged as "imperceptible"—but the trailing truck still drew attention to its indisposition by gentle tapping. The liquorice water was much in demand as the afternoon wore on, with smiles and ritual "A votre santé!" I hoped the toast would work, not being used to liquorice in quantity on a hot day—I should probably discover if it did not work later—*after* reaching Paris for preference.

It was the Marne country again now, peaceful and smiling, the scars of the first war healed. Epernay, 4.12 p.m., and a slow to 12 m.p.h. through station and yard; a great champagne factory brought no joy to the filthy wights in the cab; only liquorice water was there. The cool green waters of the Marne were right alongside at several points, making the warmth and dust in the cab stand out all the more by contrast. An appropriate saying of another sailor occurred to me: "Warm work, gentlemen! But, mind you, I would not be elsewhere!"* Correct—neither would I have been anywhere but in the cab of this beautifully running machine. I was happy sitting, in Hugenôt's seat as I had done for long stretches, leaning from the window, looking ahead through the deflector at the sun-baked, shimmering track sweeping towards me, the shining metals converging in the distance, or curving gracefully beside the placid waters of the Marne; at the corduroy of sleepers endlessly approaching and disappearing beneath. It was pleasant to look back at the long train of cars coiling and uncoiling from side to side like a whip-lash, seventeen or eighteen of them, 750 tons, or just to sit listening above the muffled roar in the cab for indicative sounds from ahead; listening, listening—to nothing! Not a single fretful sound came from any part of this complicated multi-cylindered engine—not a hiss, knock nor rattle; it was working like a dynamo. Even the exhaust was hardly audible, rushing up full and soft from the squat chimney, almost invisible in the hot, dry air, lifted nicely above the cab roof by the side wings, giving no evidence of stress nor strain. Everything about this beautiful engine from the cab forward was working sweetly and quietly; it was behaving like an express engine should, but so seldom has in my recent experience—until I came to France. A feeling of enthusiasm, of complete satisfaction, began to take possession of me; I wanted to tell the crew how delighted I was, but, hamstrung by my pitiful French, could only do so by asking Calmus to give my thoughts tongue, which would have half strangled my ecstasies, and taken the gilt off them by second-hand interpretation. Finally my feelings overcame me; I swung round impatiently and shouted to Jeunemaître and Hugenôt the only words I could think of at the moment, using appropriate gestures, "Bon! Bon! Magnifique!" The good fellows understood at once, their faces all smiles; Hugenôt dashed for the liquorice water, evidently thinking I needed cooling down a little, and perhaps I did, but it was all natural enough, and very human—I was delighted with their machine, and wanted to show it; they responded, and wanted to show me they understood, and for a space that grimy, roaring cab became an Agapemone, full of praise and joy unspeakable! This was France, thank God, where people are not afraid to let themselves go, and give free vent to their emotions. I got into the happy habit of it, too, while there, only beginning to freeze up again on landing at Dover. I repeat, it was delightful; *that* is how an engine ought to run, sweetly, easily, uncomplainingly; not as so many have run elsewhere, wheezing, groaning, knocking, a weariness unto the flesh, an exasperation instead of a joy. And this engine, by the way, was at least thirty years old. It comes into the same category in my affections as "U1" and "P33"; I can pay it no greater compliment!

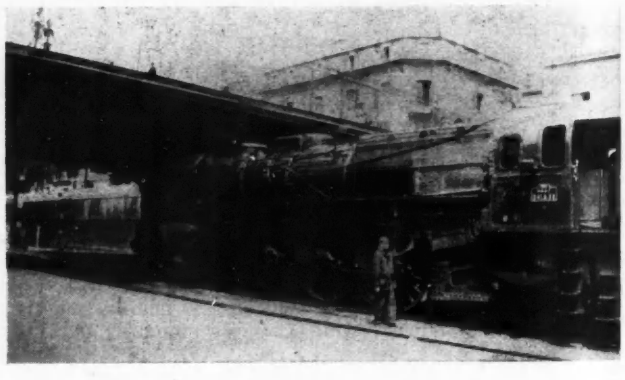


Fig. 57—No. 241-A38 at Nancy

Chateau-Thierry was run through at 4.31 p.m., the 48 miles from Chalons having been made in 42 min, 68·5 m.p.h. A great memorial stood out against the skyline on the hills to the right, commemorating the battle where, in 1918, the American Army had first, and at last, gone into action, and as all the world knows, had rolled up the enemy and won the war! History had been written in

* Nelson, at Trafalgar.

these peaceful, smiling fields—American history, at any rate. The great engine swept past and on towards Paris, smoothly, tirelessly, quietly, only an occasional tap from the truck beam reducing by a possible 1 per cent the sum of its perfection. The atmosphere in the cab was as pleasant as ever ; we were all in harmony long since, the crew evidently friends of long standing, from the good-natured insults, mostly in dumb show, that flew back and forth across the cab. Despite the speed and heavy load neither engine nor Hugenôt was really extended, the line being practically level ; in fact, the l.p. cylinders appeared to be loafing on the job, with the s.c. gauge needles generally about 12/2 respectively. A bridge restriction cut the speed to 15km near Lagny, the first respite the engine had had for a couple of hours ; clear of this, the speed again rose to the usual 65 to 70 m.p.h. Hugenôt had earned his money, but he had not worked so hard as had the fireman of "King William III" with the "Riviera Limited" of 450 tons.

We were nearing Paris now, running down long straights through dead level country ; a last quotation from my notes reads : "Riding splendid—takes curvature, crossings, &c., without the slightest objection—nothing could be better, and this an eight-coupled engine." Six pairs of gleaming metals, sidings, light engines returning to smoky sheds, factories and the usual signs of terminal approach, the train coming to a final stand in the Gare de l'Est at 5.20 p.m. O.T. The 157·5 miles from Bar le Duc had been covered non-stop in 142 min, an average speed of 66·5 m.p.h., yet 75 m.p.h. had never been exceeded. I have never experienced such sustained yet even high speed over such a distance, at any rate on a steam locomotive. It had been a delightful run, and I was sorry to say good-bye to Calmus and the merry pair of enginemen who had handled No. 241–A38 so well, and sorry, too, that they could not come with us to "La Maison Blanche." We had all earned refreshment—and needed a bath.

(To be continued)

Stress-Rupture Time Properties of Copper Tube Materials*

By R. S. D. LUSHEY† and J. McKEOWN, D.Sc., M.I.Mech.E., F.I.M.‡

The work described in this article has been carried out to provide stress data on which engineers might base their calculations of suitable wall thicknesses for copper tubes subjected to internal pressure. The data are of use for tubes for engineering applications at ordinary temperatures, where it is suspected that the safety factor used with tensile strength may be unduly conservative. Any proposals for an increase in design stress must be coupled with an assurance that there is no risk of failure with small expansion of the tube.

THE tests carried out have aimed at the determination of the highest safe stress which can be used to give long life, without at any time giving rise to excessive deformation, i.e. swelling of the pipe. The first of these requirements might be met by finding the highest stress which does not give rise to continuous creep in the copper, but at ordinary temperatures such a stress might produce an amount of initial deformation, plus deformation arising from primary creep, too great to be acceptable. In such cases the stress would have to be that which produces an acceptable amount of deformation and might be much lower than that corresponding to non-continuous creep.

The coppers examined in the present work included the deoxidised coppers commonly used in the manufacture of tubes, i.e. arsenical deoxidised copper to B.S.S. 1174, and non-arsenical deoxidised copper to B.S.S. 1172. To complete the picture H.C. tough pitch copper to B.S.S. 1036 was included. All three coppers were examined in the three conditions soft, half-hard and hard.

The maximum stress in a thin-walled tube subjected to internal pressure is the circumferential stress and this acts at right angles to the direction of the drawing deformation applied in the manufacture of the tube. Since equipment was not available for internal pressure creep tests on actual tubes an indirect approach to the determination of allowable stresses had to be employed.

The materials were obtained as rolled strips of sufficient width to enable creep specimens to be cut and loaded in a direction at right angles to the rolling direction, i.e. reproducing as closely as possible the relationship of the circumferential stress to the drawing direction in tubes. These strips had been produced by rolling to give the same mechanical properties as soft, half-hard and hard tubes in each of the three coppers.

Tensile creep tests have been made at 95, 90, 85 and 80 per cent of the tensile strengths of the strips, this tensile strength being obtained in the transverse direction. The creep tests were continued to fracture or to 5000 hours in those specimens which did not fracture. The tests were made at 100 deg. Fah. to avoid any possible effects of laboratory temperature fluctuations. It is considered that this temperature is not sufficiently above normal atmospheric temperature to produce any softening or other deleterious effects on the coppers even in times of the order of one year.

In all the materials in the soft condition the initial extension of the creep specimens was very large at 95 and 90 per cent of the tensile strength. The amount of subsequent creep was small in the two deoxidised coppers at 90 per cent of the tensile strength and the life greater than 5000 hours. It would appear, however, that in all the coppers in the soft condition the safe stress which would give long life combined with the avoidance of excessive swelling of a tube would need to be much lower than 90 per cent of the tensile strength, the suggested value being that corresponding to the 0·1 per cent proof stress, which is of the order of 5 tons per square inch, i.e. about 30 per cent of the tensile strength. Such a stress would, of course, give an initial expansion of 0·1 per cent, but this would be followed by a further limited expansion due to creep.

In the half-hard and hard conditions the H.C. copper to B.S.S. 1036 showed continuous creep at a stress 80 per cent of the tensile strength and thus, although the 0·1 per cent proof stress is about 85 per cent of the tensile strength, a safe stress in this material would be lower, possibly as low as 60 per cent of the tensile strength. By the same criteria the half-hard and hard deoxidised coppers would appear to have a safe stress of the order of 80 per cent of the tensile strength.

It thus appears that in copper tubes in non-corrosive environments the wall thickness corresponding to a given steady internal pressure or, conversely, the safe steady pressure for a given wall thickness, could be calculated from the following percentages of the tensile strength.

	Per cent of tensile strength		
	Soft	Half-hard	Hard
H.C. copper to B.S.S. 1036	30	60	60
Arsenical deoxidised copper to B.S.S. 1174	30	80	80
Non-arsenical deoxidised copper to B.S.S. 1172	30	80	80

The values so obtained would ensure against the occurrence of continuous creep and would produce initial plastic strains of the order 0·1 per cent or less.

The values given in this table have been

* Communication from the British Non-Ferrous Metals Research Association ; Report R.R.A. 997 P, based on a confidential report made available to B.N.F.M.R.A. members in May, 1953.

† Research assistant, B.N.F.M.R.A.

‡ Head of mechanical testing section, B.N.F.M.R.A.

TABLE I—*Hardness Tests*

Material	Temper	B.N.F. mark	V.P.N. Average	V.P.N. Range
H.C. Copper to B.S.S. 1036	Soft	POG	52·7	51·3– 53·3
	Half-hard	POH	94·8	92·8– 98·0
	Hard	POJ	111	109 –113
Arsenical deoxidised copper to B.S.S. 1174	Soft	POK	56·0	55·3– 56·7
	Half-hard	POL	104	103 –106
	Hard	POM	124	122 –126
Non-arsenical deoxidised copper to B.S.S. 1172	Soft	PON	50·4	49·8– 51·3
	Half-hard	POO	101	99·4–102
	Hard	POP	114	111 –115

Sixteen impressions were made across the width of the rolled strip using a load of 10kg.

TABLE II—*Analyses of the Coppers Tested*

Copper	Sb, per cent	As, per cent	Bi, per cent	Fe, per cent	Pb, per cent	P, per cent	Ni, per cent	Ag, per cent	Sn, per cent	Zn, per cent	Te,	O_2
H.C. copper to B.S.S. 1036	N.d.	0·002	0·0003	0·001	0·005	N.d.	0·002	0·005	0·005	N.d.	N.d.	0·018
Arsenical deoxidised copper to B.S.S. 1174	0·008	0·35*	0·003	0·001	0·03*	0·04*	0·06	0·005	0·04*	0·001	0·004	—
Non-arsenical deoxidised copper to B.S.S. 1172	N.d.	0·002	0·0006	0·0002	0·005	0·04*	0·003	0·005	0·005	N.d.	N.d.	—

N.d.= Not detected.
*=Chemical analysis.

based on transverse tensile strengths. Longitudinal tensile strengths have been found to be 1 to 2 tons per square inch lower than the transverse strengths. If, therefore, the longitudinal tensile strength of the tube material is used (determined by a longitudinal test on an actual tube) an additional factor of safety will be introduced into the calculations of safe pressure or suitable wall thickness.

It should be mentioned that the creep tests showed that in all three conditions the arsenical deoxidised copper had somewhat higher resistance to creep than the non-arsenical deoxidised copper. In view of the limited number of tests it has been possible to carry out it is not felt that this difference between these two coppers is sufficiently pronounced to justify differentiating between them in the above table.

Materials

The materials tested were obtained as rolled strip 8½in wide by 16 s.w.g. in three tempers, soft, half-hard and hard, corresponding to the tempers available in tube.

All three coppers were processed as follows :—

(1) 4in cake preheated to 850 deg. to 900 deg. Cent. and hot rolled in eleven passes to $\frac{5}{16}$in ; annealed and pickled, 25½in wide, when hot rolled.

(2) Cold rolled $\frac{5}{16}$in to 0·168in, annealed and pickled.

(3) Cold rolled crosswise to 0·125in, annealed and pickled.

(4) Hard temper, cold rolled 0·125in to 0·064in ; half-hard, soft, cold rolled 0·125in to 0·080in, annealed and pickled.

(5) Hard temper, finished at stage (4) ; half-hard, cold rolled 0·080in to 0·064in ; soft, cold rolled 0·080in to 0·064in, annealed and pickled.

All annealing treatments one hour at 500 deg. Cent.

The width of the strip was such that creep specimens could be cut transverse to the direction of rolling and consequently the creep stress was applied in the same direction relative to the working operation as the circumferential stress in tubes subjected to internal pressure. Hardness measurements made at intervals across the width of the strips showed that the homogeneity was quite good (Table I). The analyses of the coppers are given in Table II and the grain sizes in Table III.

Table III—*Grain Sizes of Copper Strips*

	Grain diameters, mm		
	Soft	Half-hard	Hard
H.C. copper to B.S.S. 1036	0·030 (L) 0·025 (T)	0·020 (L) 0·030 (T)	0·012 (L) 0·015 (T)
Arsenical deoxidised copper to B.S.S. 1174	0·045 (L) 0·055 (T)	0·036 (L) 0·036 (T)	0·025 (L) 0·025 (T)
Non-arsenical deoxidised copper to B.S.S. 1172	0·031 (L) 0·021 (T)	0·014 (L) 0·020 (T)	0·020 (L) 0·018 (T)

L = diameter in direction of rolling.
T = diameter across direction of rolling.

Tensile Tests

Twelve creep specimens were machined from each strip and the ordinary mechanical properties of specimens 1 and 12 determined. Additional specimens were cut longitudinally from each hard strip and their properties determined. The collected results are given in Table V and require no comment except to note that the tensile strengths of longitudinal specimens were slightly lower than those of transverse specimens.

Stress-Rupture Time Tests

The laboratory temperature was known to vary from 60 deg. to 90 deg. Fah. during the year and hence to avoid possible effects of the variable temperature on creep readings the tests were carried out at a temperature of 100 deg. Fah. (37·8 deg. Cent.). The equipment used has been described elsewhere.[1] The specimens were loaded at various percentages of the tensile strength as determined in the preliminary tensile tests, and subjected to these stresses for 5000 hours or to fracture, whichever occurred earlier. In those specimens which gave less than 20 per cent initial extension on loading readings of creep strain were taken at frequent intervals and the creep curves plotted. The detailed results of the tests are given in Table IV and are considered below for the three conditions of the materials—soft, half-hard and hard.

Table V—*Tensile Tests*

Material	Temper	0·1 per cent proof stress, tons/sq in	Tensile strength, tons/sq in	$E \div 10^6$ lb/sq in	Elongation per cent on 2in			P.S./T.S., per cent
					Local	General	Total	
Specimens cut transversely to the direction of rolling :								
H.C. copper strip to B.S.S. 1036...	Soft	4·41	14·8	22·5	18	41	59	30
	Soft	4·99	14·8	18·2	8	44	52	33
	Half-hard ...	16·1	18·7	20·6	10	2	12	86
	Half-hard ...	16·3	18·7	19·2	14	3	17	87
	Hard	19·8	23·8	18·6	5	1	6	83
	Hard	19·4	23·4	18·7	3	1	4	82
Arsenical deoxidised copper to B.S.S. 1174	Soft	4·63	16·1	20·3	8	44	52	29
	Soft	4·80	16·1	18·3	8	44	52	30
	Half-hard ...	16·8	19·2	20·3	13	2	15	88
	Half-hard ...	18·0	19·3	20·0	12	4	16	93
	Hard	21·6	25·8	22·5	4	½	4½	84
	Hard	23·0	25·6	19·1	3	1	4	90
Non-arsenical deoxidised copper to B.S.S. 1172	Soft	4·48	15·0	19·1	16	39	55	30
	Soft	4·55	14·4	21·8	14	39	53	31
	Soft	—	15·0	—	—	—	—	—
	Half-hard ...	17·9	19·5	19·5	9	½	9½	92
	Half-hard ...	17·7	19·5	18·5	9	½	9½	91
	Hard	21·1	23·8	20·6	8	½	8½	88
	Hard	21·0	23·7	19·5	5	½	5½	88
Specimens cut longitudinally to the direction of rolling :								
H.C. copper strip to B.S.S. 1036...	Hard	20·0	21·6	17·8	4	2	6	92
	Hard	19·2	21·7	17·4	4	2½	6½	89
Arsenical deoxidised copper to B.S.S. 1174	Hard	22·2	24·2	19·5	6½	—	6½	92
	Hard	22·0	24·0	19·4	4	—	4	92
Non-arsenical deoxidised copper to B.S.S. 1172	Hard	21·2	22·4	18·7	8	—	8	95
	Hard	20·8	22·7	20·0	5	3	8	92

Table IV—*Stress Rupture Properties of Commercial Coppers*

Material	Temper	Stress		Plastic strain per cent in-hours							Elongation per cent on 5in			Duration in hours	Remarks
		Actual tons/sq in	Percentage of T.S.	0	500	1000	2000	3000	4000	5000	Local	General	Total		
Specimens cut transversely to the direction of rolling :															
H.C. copper to B.S.S. 1036	Soft	14·1	95	>20	—	—	—	—	—	—	3	46	49	17 min	Broken
	Soft	13·3	90	>20	—	—	—	—	—	—	5	37	42	12	Broken
	Soft	12·6	85	>20	—	—	—	—	—	—	4	43	47	770	Broken
	Soft	11·8	80	12	>20	—	—	—	—	—	—	—	27	5000	Not broken
	Half-hard ...	17·8	95	0·37	—	—	—	—	—	—	15	1	16	5 min	Broken
	Half-hard ...	16·8	90	0·14	—	—	—	—	—	—	5½	2	7½	22	Broken
	Half-hard ...	15·9	85	0·10	0·86	1·58	—	—	—	—	5	3	8	1850	Broken
	Half-hard ...	15·0	80	0·05	0·34	0·45	0·64	0·79	0·94	1·10	—	—	—	5000	Not broken
	Hard	22·4	95	0·24	—	—	—	—	—	—	2½	1	3½	24 min	Broken
	Hard	21·2	90	0·38	—	—	—	—	—	—	1½	1	2½	15 min	Broken
	Hard	20·1	85	0·11	—	—	—	—	—	—	3	3	6	150	Broken
	Hard	18·9	80	0·08	0·88	1·40	2·65	—	—	—	4	3	7	2550	Broken
Arsenical deoxidised copper to B.S.S. 1174...	Soft	15·3	95	24 at 24 hours		*	—	—	—	—	—	—	—	5000	Not broken
	Soft	14·5	90	16 at 24 hours		*	—	—	—	—	—	—	—	5000	Not broken
	Half-hard ...	18·3	95	0·25	0·38	0·38	0·38	0·38	0·38	0·38	—	—	—	5000	Not broken
	Half-hard ...	17·4	90	0·08	0·11	0·12	0·12	0·13	0·13	0·13	—	—	—	5000	Not broken
	Hard	24·4	95	0·21	0·35	0·36	0·36	0·36	0·37	0·37	—	—	—	5000	Not broken
	Hard	23·1	90	—	0·014	0·019	0·026	0·027	0·027	0·028	—	—	—	5000	Not broken
Non-arsenical deoxidised copper to B.S.S. 1172	Soft	14·1	95	>20	—	—	—	—	—	—	3	32	35	1550	Broken
	Soft	13·3	90	25 at 24 hours		—	—	—	—	—	—	—	25	5000	Not broken
	Half-hard ...	18·5	95	0·34	0·52	0·53	0·55	0·56	0·57	—	4	—	4	4660	Broken
	Half-hard ...	17·6	90	0·10	0·17	0·18	0·19	0·20	0·20	0·20	—	—	—	5000	Not broken
	Hard	22·6	95	0·21	—	—	—	—	—	—	1	1	2	84	Broken
	Hard	21·4	90	0·33	0·61	0·62	0·63	0·64	0·65	0·66	—	—	—	5000	Not broken
Specimens cut longitudinally to the direction of rolling :															
H.C. copper to B.S.S. 1036	Hard	18·4	85	0·06	0·31	0·38	0·47	0·54	0·60	—	—	—	—	—	—
Arsenical deoxidised copper to B.S.S. 1174...	Hard	22·9	95	0·08	0·12	0·12	0·12	0·12	0·12	—	—	—	—	—	—
Non-arsenical deoxidised copper to B.S.S. 1172	Hard	21·4	95	0·08	0·15	0·15	0·16	0·16	0·16	—	—	—	—	—	—

* In these cases no further readings of extension were taken. However, the loading levers of the creep testing machines remained approximately horizontal during the rest of the 5000 hours testing time, indicating that further plastic strain of the specimens was small.

Soft Condition.—In all three materials the initial strain on loading to 95 and 90 per cent of the tensile strength was greater than 20 per cent. Specimens of the H.C. copper at these stresses broke in short times and it was necessary to carry out further tests at 85 and 80 per cent of the tensile strength. At 85 per cent the life was 770 hours, but at 80 per cent the life was greater than 5000 hours, the extension in this time being 27 per cent. The arsenical deoxidised copper specimens had lives in excess of 5000 hours, both at 95 and 90 per cent of the tensile strength. The non-arsenical deoxidised copper specimens loaded at 95 per cent of the tensile strength broke in 1550 hours, the specimen loaded at 90 per cent having a life greater than 5000 hours.

While a stress as high as 90 per cent of the tensile strength in the case of the two deoxidised coppers and 80 per cent in the case of the H.C. copper would undoubtedly give long life, it is clear that the deformations resulting from such high stresses could not be tolerated in practice. A much lower stress, producing much less deformation, would have to be used, and it is suggested that a suitable stress would be the 0·1 per cent proof stress which in all three coppers in the soft condition is of the order of 4·5 to 5 tons per square inch. This stress would give an initial plastic strain of 0·1 per cent and some further plastic strain of limited amount would result from slow creep.

Half-Hard Condition.—The H.C. copper specimens loaded at 95 and 90 per cent of the tensile strength broke in short times and it was necessary to come down to 80 per cent of the tensile strength before a life in excess of 5000 hours was obtained. The arsenical deoxidised copper specimens had lives greater than 5000 hours at 95 and 90 per cent of the tensile strength, the amount of creep in this time at these stresses being 0·38 and 0·13 per cent respectively. Also at both these stresses continuous creep appeared to have ceased after about 2000 hours. In the non-arsenical deoxidised copper specimen stressed at 95 per cent of the tensile strength creep was slow, but continuous, during the first 4000 hours and the specimen broke in 4660 hours. At 90 per cent of the tensile strength creep ceased at between 2000 and 3000 hours, the total at 5000 hours being only 0·2 per cent.

Hard Condition.—In the H.C. copper a stress as low as 80 per cent of the tensile strength produced continuous creep and fracture occurred in 2550 hours. In the arsenical deoxidised copper specimens stressed at 95 and 90 per cent of the tensile strength creep continued throughout the 5000-hour test period, but at a very slow rate. In the case of the non-arsenical deoxidised copper the specimen loaded at 95 per cent of the tensile strength had a short life, while the one stressed at 90 per cent had a life greater than 5000 hours, but showed continuous creep throughout this time.

Reference to Table V, giving the results of the tensile tests on the materials in the "as-received" conditions, shows that for the half-hard and hard arsenical and non-arsenical deoxidised coppers the 0·1 per cent proof stress was of the order of 90 per cent of the tensile strength. The creep tests show that a stress of the order of the 0·1 per cent proof stress will give a life greater than 5000 hours, but with continuous creep at a very low rate. A safe stress in these two materials in the half-hard and hard conditions would therefore appear to be less than 90 per cent of the tensile strength and a value of 80 per cent is suggested.

In the case of the half-hard and hard H.C. copper the 0·1 per cent proof stress is, from Table V, 80 to 85 per cent of the tensile strength, while in the creep tests a stress of 80 per cent of the tensile strength produced a high rate of creep and fracture or risk of fracture. It would appear that in these two tempers a safe stress in this material would require to be of the order of 60 per cent of the tensile strength.

TABLE VI—*Tensile Tests Before and After 5000 Hours Creep Testing*

Material	Temper	Creep stress, percentage of tensile strength	Tensile strength		Elongation per cent on 2in					
			Before	After	Before			After		
			Tons/sq in	Tons/sq in	Local	General	Total	Local	General	Total
H.C. copper to B.S.S. 1036	Soft	80	14·8 14·8	14·7	18 8	41 44	59 52	20	38	58
	Half-hard	80	18·7 18·7	18·9	10 14	2 3	12 17	12	6	18
Arsenical deoxidised copper to B.S.S. 1174	Soft	90	16·1	16·9	8	44	52	8	43	51
		95	16·1	16·8	8	44	52	12	43	55
	Half-hard	90	19·2	20·1	13	2	15	15	2	17
		95	19·3	20·0	12	4	16	15	2	17
	Hard	90	25·8	26·9	4	½	4½	5	—	5
		95	25·6		3	1	4			
Non-Arsenical deoxidised copper to B.S.S. 1172	Soft	90	15·0 14·4	15·2	16 14	39 39	55 53	25	37	62
	Half-hard	90	19·5 19·5	20·1	9 9	½ ½	9½ 9½	12	—	12
	Hard	90	23·8 23·7	24·3	8 5	½ ½	8½ 5½	13	—	13

Tensile Tests on Creep Specimens

The results of tensile tests on creep specimens which had lives greater than 5000 hours in the creep tests are given in Table VI. A comparison is made with the results obtained on specimens not subjected to creep testing. No decrease in tensile strength or in ductility was found to result from exposure to high stresses during the 5000-hour creep tests. In the case of the half-hard and hard non-arsenical deoxidised coppers there was, in fact, a slight increase in both ductility and tensile strength, as a result of holding the specimens for 5000 hours at 100 deg. Fah. at 90 per cent of the tensile strength.

Long Time Creep Test at 20 deg. Cent. (68 deg. Fah.)

This test is being carried out in a constant temperature room on a specimen of the non-arsenical deoxidised copper in the soft condition. The specimen is stressed at 75 per cent of the tensile strength (actual stress 11·1 tons per square inch) and the test had (by May, 1953) been running for 500 days (12,000 hours). The initial extension was 9·5 per cent; this rose to 10·0 per cent in one day, and 11·5 per cent in thirty-one days. For the remainder of the time the extension has remained at 11·5 per cent, i.e. no creep has occurred in the past 470 days.

This test again indicates that in the soft materials, while a stress which is a high percentage of the tensile strength will not necessarily lead to failure, the use of such a stress would be undesirable in practice, because of the large amount of deformation occurring as initial strain and augmented to some extent by creep in the first month or so of the life. In the cold-worked materials a large proportion of this deformation has already been taken up by the cold working process. The advantage of using the cold-worked materials lies in this avoidance of excessive deformations.

Effect of Direction of Working on Creep Behaviour

Table IV contains the results of three tests made on specimens of the hard strip in each of the three materials, the specimens being taken so that the applied stress in the creep tests was parallel to the direction of rolling in the strip. Comparing these results with those obtained from transverse specimens it is seen that in each material the rate of creep of the longitudinal specimens is considerably lower than in the transverse specimens.

Reference

[1] J. McKeown: "Creep and Fatigue Testing Equipment in the Laboratories of the British Non-Ferrous Metals Research Association," *Metallurgia*, September, 1950, page 189.

Mechanisation of Slow-Sand Filter Bed Cleaning

During the last three years extensive trials have been conducted by the Metropolitan Water Board with light agricultural tractors, specially adapted for transporting sand in filter beds, in connection with investigations being undertaken by the Board of various methods of cleaning and resanding slow-sand filter beds by mechanical means. Some information on this work is given in a recent report of the Board's Works and Stores Committee. The use of these tractors has increased considerably the output per man in the cleaning and resanding of the beds, it is stated, has enabled the beds to be cleaned more rapidly, thus increasing the effective output of filtered water per bed, and has resulted in substantial savings in costs.

An experimental machine for skimming the surface of the sand in the filter beds has also been developed and has given satisfactory results. It is expected that the use of such machines in conjunction with tractors will further reduce the cost of cleaning the beds. In addition, a design has been prepared of a trenching machine for use when resanding the beds and it is proposed to construct one for experimental purposes.

The committee's report proposes the general mechanisation of filter bed cleaning to be extended to all the Board's existing works, with the exception of Kew Bridge, where the filters are shortly to be abandoned. For this purpose it is proposed to purchase thirty-three additional tractors and other mechanical plant of the types which have proved satisfactory, and also to proceed with the development and works trials of four skimming machines and one experimental trenching machine. The servicing, maintenance and overhaul of all the plant will necessitate the establishment of a special organisation and the equipping of two central workshops, one at Hampton and the other at Lee Bridge, by the conversion of parts of existing buildings. It will be recalled that other experimental work for various new filter beds at present under construction has also been carried out by the Board. In our issue of June 26, 1953, page 905, we gave an account of a model of the proposed sand-washing caisson and bridge to be used on some of the filter beds at Ashford Common; a sand-handling bridge and central sand-washing plant is also to be used at Ashford Common.

Launch of Coastal Minesweeper.—On Wednesday, June 2nd, Her Majesty's coastal minesweeper "Highburton" was launched from the Southampton yard of J. I. Thornycroft and Co., Ltd. The ship, which is designed for operating in shallow waters, is wood planked over aluminium alloy frames, has a length of 152ft by 28ft 9in beam and is the first of this class to be powered by the "Deltic" diesel engine built by D. Napier and Son, Ltd.

International Railway Congress, 1954*

(*Continued from page* 790, *May* 28*th*)

No. II—ENGINEERING DEVELOPMENTS

WHILE each section of the Congress discussed certain selected points in detail, it was possible to discern, from informal talks and from the interest shown in the various excursions arranged for delegates, one major trend of development, or inclination, on the railways represented at this gathering: the advancement of electrification. It is true that there was no out-and-out comparison between the merits of electric and steam traction, or of other forms of motive power with them both; but the general replacement of steam locomotives was none the less implied. The division of the technical work of the Congress into five specialised sections tends to result in the discussion of detail rather than broad principles; but the bringing together of such a wealth of railway experience was of inestimable value, while to British delegates and observers the proceedings were naturally seen against the background of the impending large-scale developments at home foreshadowed in the opening speech of Sir Brian Robertson.

For engineers in all branches of the railway service the advancement of electrification may well be regarded as the cornerstone of this Congress. On the motive power and rolling stock side the basic characteristics of existing forms of electric traction were collated and discussed at length. For civil engineers each extension of electric traction brings the prospect of heavier traffic, increased wear on rails, the need for increased attention to "top" and "line," while the full benefits of electric traction cannot be realised without a proportionate increase in line capacity through the agency of modern colour light signalling. Against these various needs must be set the continuing shortages of skilled staff, so that increased maintenance of the track and improved regulation of the traffic has to be secured in the face of possible reductions rather than increases in the personnel so engaged. These trends were to be clearly discerned in many of the subjects discussed in the technical section meetings. At the same time, while there were suggestions that the steam locomotive, if not necessarily to be regarded as obsolescent, is nearing the end of its development as a form of first-line motive power: it is none the less evident that in many countries it is enjoying a very lusty and virile old age.

The actual subjects discussed by the sections were as given below. In each case the questions had been submitted to all railway administrations belonging to the International Railway Congress Association, and the subject matter of the replies had been collated and summarised by a delegate having qualifications in that particular field. In the following list the names of the reporters, as they are known, are given below each question:

Section I: WAY AND WORKS

Question 1.—What are the present tendencies relating to the organisation of the maintenance of the permanent way: methods of determination of the works to be done and in particular possibilities of the use of detecting-recording coaches; planning of the works, effects of mechanisation; importance of the side tracks for the movement of the gangs and the mechanical devices. Economic and financial aspect.

By Dr.-Ing. habil. G. Schramm (Germany).

Question 2.—Modernisation of station buildings and methods employed in financing modernised projects. Standardisation of unit construction applied to railway buildings.

By Dr. F. F. C. Curtis (Great Britain).

Section II: LOCOMOTIVES AND ROLLING STOCK

Question 3.—Technical and economical investigation of the basic characteristics of electric traction systems now in use, with a view to decide whether, and to what extent, there are relevant reasons for preferring one system to another. In particular are there are any reasons in regard to (*a*) power supply, (*b*) overhead line and fixed track installations, (*c*) motive power units, (*d*) working and maintenance costs.

By S. B. Warder (Great Britain).

Question 4.—Means and methods to improve the efficiency of steam locomotives: (*a*) increase of steam pressure, (*b*) types of grates, (*c*) superheating of the steam, (*d*) preheating of the feeding water, (*e*) feed water treatment, &c.

By R. Squilbin (Belgium).

Section III: WORKING

Question 5.—Radiophonic communications in railway working.

By S. G. Hearn (Great Britain).

Question 6.—(*a*) Remote operating of signalboxes: technical realisation, working orders; (*b*) electric working and control devices for hinged and flexible points and switches; control of accidental trailing of the switch blade.

By J. Nogues (Spain).

Section IV: GENERAL

Question 7.—Modernisation of the methods to be adopted for recruiting the staff in number and qualification. Harmonious renewal of the various ranks, indispensable reserve lists, ratio of the permanent and temporary staff. Part played by the medical service in the recruiting.

By F. Lemass (Republic of Ireland).

Question 8.—Determination of the principles of geographical and functional organisation of a railway system. Simplification and retrenchment of the administration of railways.

By R. Dugas (France).

Question 9.—Railway participation in road transport undertakings.

By Dr. G. Dreyer (Switzerland).

Section V: LIGHT RAILWAYS AND COLONIAL RAILWAYS

Question 10.—Wear of rails on curves: (*a*) characteristics of track laying on curve and details of rolling stock liable to cause premature wear of rails; (*b*) running effects of locomotives and motor coaches with motor bogies; (*c*) results of the investigations made and proposed remedies; use of rail lubrication processes.

By L. Ripert (France).

Question 11.—Protection of overhead lines, substations, locomotives and motor coaches against accidents of electrical origin (excess voltage, overloads, short circuits and lightning).

By J. F. M. De Boeck (Belgium).

* Held in London, May 19th to 26th.

ELECTRIC TRACTION

We have chosen for detailed reference those sections of the Congress discussions that were of immediate interest to engineers, and in view of its particular significance at the present time in Great Britain electric traction is taken first. The Congress itself carried out a technical and economic investigation of the basic characteristics of the various systems now in use in many parts of the world, but by way of background to the problem in this country certain aspects of the case for electrification may be considered. It is perhaps not generally realised that already one quarter of the total passenger train miles worked on British Railways is electrically operated. This is a striking commentary upon the volume of suburban traffic around London, but no less upon the intensity of the longer distance traffic worked by multiple-unit trains on the Southern Region. The advocates of electric traction stress the cleanliness of service, and the fact that at present some 15,000,000 tons of good quality coal is used in steam locomotives, often to the detriment of stations, rolling stock, and property alongside the lines.

So far the operating benefits derived, particularly in the experience of the Southern Region, have been very great indeed, though in the case of that Region it is important to appreciate that on all routes the freight traffic is so relatively small that the bulk of it can be conveyed at night, and the lines left freer for passenger trains during the daytime. Experience has so far to be gained in Great Britain on a heavily worked main line used not only by many long-distance passenger and freight trains, but including a string of important junctions, centres for the collection and distribution of merchandise conveyed by rail, where the volume of line-side marshalling and shunting movements have tended to increase enormously in recent years. On routes such as these the key to better operation would seem to be as much with the signalling and general regulation of the traffic as with the form of motive power, and although a case can undoubtedly be made for a large scale changeover to electric traction the general adoption of continuous brakes on freight stock would appear to be a necessary adjunct if the full operating benefits are to be derived. Maybe some such development is envisaged in the remarks of Sir Brian Robertson at the opening of the Congress. One point seems fairly certain—there would be no difficulty in providing the necessary power. It is estimated that the conversion of 4000 route miles of heavy main line over a fifteen-year period would entail a consumption of some 60MW per annum, whereas the present annual increase to the capacity of the British Electricity Authority is some 1500MW. It would seem, therefore, that the B.E.A. could readily absorb the additional load imposed by main line railway electrification.

The Congress discussed the various electric traction systems now in use, and one noticeable point emerged. Where a country had already installed one system of electric traction to a considerable extent there seemed no disposition to regard that system as sacrosanct, and the one to be adopted for future extensions. In Great Britain, for example, we have the largest suburban electrified system anywhere in the world, equipped with the 660V d.c. system using "third rail" pick-up; yet on lines recently equipped 1500V direct current, with overhead line, has been used, and it is intended that this should be the standard for future work. In passing, it may be remarked that it was rather extraordinary that the Southern Region system should not even be considered in the deliberations of the Congress. Summary No. 1 of the report on Question 3, indeed, read: "The investigations of the reporters show that for all practical purposes the only systems suitable for extensive railway application are:

Direct current	1500V
Direct current	3000V
Alternating current	Low frequency at 11/16kV
Alternating current	Standard frequency at about 25kV

This summary was adopted without amendment.

It may be noted that this investigation came at a time when electric traction had been in use for roughly fifty years. Circumstances have changed very much since a technical and economic investigation upon the subject had last been undertaken by the International Railway Congress Association; that was at the Congress in Cairo twenty years ago, when comparisons were made for and against the replacement of steam by electric traction. In the present Congress the examination of existing systems under the headings quoted earlier in this article did not,

as might be expected, show any clear-cut advantage of one system over all others. Each has features in the technical, operational and economic fields which make one or other of them particularly suitable in certain circumstances. The power supply system does not normally determine the choice of electrification system, as all can be arranged for supply from systems feeding other loads. This inquiry has, however, shown that in various countries there is a wide diversity of tariffs, and further study of these and of the possibility of special rates being given to the railways is recommended. Prior to the preparation of the special report which was discussed at the Congress itself, Question 3 had been the subject of two lengthy and most comprehensive reports. One of these was compiled by Mr. Warder himself and was based on the replies received from the countries of the British Commonwealth, North and South America, Burma, Egypt, Irak, Iran, the Republic of Ireland, and the Scandinavian countries. The second report was prepared by Dr. Ing. C. Guzzanti, Professor of Electric Traction at the University of Pisa, and covered replies from all participating countries of the European Continent, except Scandinavia. These two reports represent invaluable works of reference on the subject, and are printed in full in the *I.R.C.A. Bulletins* for October, 1953 (Warder), and March, 1954 (Guzzanti).

With regard to fixed installations, both in substations and overhead contact lines, the a.c. systems appear to show certain advantages over direct current. For example, the a.c. systems permit the use of smaller cross sections in the contact system, while the lower weight of the contact line permits a reduction in the strength of the supporting structures and their foundations. It was generally agreed, however, that the advantages of the light-weight overhead system are most pronounced on railways of simple formation in open country and are of less importance in built-up areas with multiple tracks, with many junctions and places where there is difficulty in obtaining the necessary clearances. A good deal of discussion took place regarding the 50-cycle system and its possibilities, and while it is the successful equipment recently of the Thionville–Valenciennes line of the French National Railways that has tended to bring the system to the fore, it was pointed out that an installation had been working in Hungary for twenty years ; there is another in Turkey, while in France a further big scheme on the 50-cycle system was projected. The reduction in first cost of much of the equipment for this system, as compared with other systems of electric traction, might well favourably affect the possibility of electrifying lines which would not justify electrification on the other systems. In Great Britain the 50-cycle system has been installed experimentally on the Lancaster–Morecambe–Heysham line of the London Midland Region. Each train set consists of an 860 h.p. motor coach, non-driving trailer, and driving trailer. The motor coach is supplied through a single pantograph from the contact wire at 6600V, 50 c/s. The maximum service speed with these local trains is 60 m.p.h. One of the motor coaches was on show in the Willesden exhibition. While noting the possibilities with this particular form of electric traction its introduction on any scale in this country would provide yet a third system, and would seem, as we see it, to render still more remote any chances of eventual standardisation of traction systems on British Railways. Electric traction is in a state of fairly rapid evolution. There is a natural tendency to explore each new development as it comes along ; but while individual schemes may operate as self-contained units for a time, their eventual extension may bring them adjacent to lines electrified on a different system with consequent drawbacks in the handling of through traffic. Yet without the trial of new systems there would be no progress. How far to standardise, and how far to experiment with new methods is always one of the most delicate questions to be faced by any railway administration.

In the realm of motive power there is, with all systems, a marked trend towards the total adhesion type of locomotive, with bogie-mounted motors, and on this account one of the most important mechanical problems for designers is the improvement of riding at high speed. It was, however, a little surprising to read in the special report prepared by Mr. Warder that with the exception of the new C_0–C_0 locomotive, of which an example was shown at the Willesden exhibition, none of the modern units are " permitted " to run at over 70 m.p.h. It is certainly true that some of the smoothest riding with non-steam locomotives in this country at the present time is provided by the 1750 h.p. diesel-electric locomotives of the Southern Region, which have the 1–B_0–B_0–1 wheel arrangement. On the other hand, speeds very considerably in excess of 70 m.p.h. are regularly run in ordinary service by total adhesion locomotives, both in this country and elsewhere. Having regard to the conditions of service in the various countries satisfactory locomotives have been built for all classes of traffic, and the consensus of opinion was that a steady improvement in the quality of performance was to be noted with all types. With the outstanding example of the Southern Region electrified system in this country Summary 19 of the question might seem almost a platitude :

" The multiple-unit type of electric train is an important feature of most electrification schemes which cater for passenger traffic, and it is considered that there is still further scope for its exploitation."

The economic side of the investigation did not lead to any definite conclusions in favour of one system or another, since the widely differing conditions which exist between countries make it impossible to place any great reliance on a direct comparison on the cost of their respective systems. Both in respect of first costs and of maintenance charges the diversity and type of railway systems, no less than the age of existing equipment and locomotives introduce variations probably greater than those arising from the inherent differences in the systems of traction used. Mr. Warder concluded his special report thus : " There seems to be insufficient information at present to confirm any definite superiority of any of the four main systems in all respects which would permit anyone to be preferred over the others under conditions at present obtaining. The evidence at present available suggests that it is unlikely that in the foreseeable future one system will prove to be the best for all railways having regard to their very diverse characteristics. In any case, such superiority, wherever it exists, is unlikely to be sufficient to justify the cost of replacing an existing system of the other three types considered, with the one having only a marginal advantage. On most lines the choice between systems can only be made by detailed comparative estimates, taking all the special factors on the lines concerned into account."

(To be continued)

Mechanised Production of Electric Motor Stators

A new factory for the winding of stators for electric motors up to 5 h.p. has been opened by Brook Motors, Ltd., at Barugh Green, 4½ miles from Barnsley. An electronically controlled conveyor system supervised by one girl enables the necessary materials and components to be supplied to 185 winders without delay and with a minimum of handling, as described below.

BECAUSE of the post-war shortage of female labour in Huddersfield, where a.c. motors have been made for fifty years by Brook Motors, Ltd., the company decided that the increased demand for its products could best be met by opening satellite works elsewhere. As an interim measure a winding works was started in 1945 in an old flax mill in Peel Street, Barnsley. It was staffed by local girls who had previously been trained in the company's Huddersfield works and the experiment proved so successful that additional rooms in the mill were taken over for winding. In the meantime a site for a new factory was acquired about 4½ miles from Barnsley and building was begun in 1951. The factory has now been in production for several months and when it was formally opened on May 28th last by Sir John Keeling the five-hundred-thousandth motor stator wound at Barnsley was taken off the production line.

In Fig. 1 we show an aerial view of the factory which occupies a site of 450,000 square feet at Barugh Green, 4½ miles from Barnsley and 14 miles from Huddersfield. The floor space at present covered by the works is 110,000 square feet, which leaves considerable room for expansion. The number of employees is now 450 and an ultimate total of 1000 employees is envisaged.

The main function of the new works is the winding of electric motor stators ranging in output from fractional horse power to about 5 h.p. Stator frames, with laminated cores pressed in, are brought by road to Barnsley from the company's Huddersfield works. In the Barnsley factory the stator coils are wound and inserted in the stator slot, end connections are made, and terminal blocks are fitted ; the wound stators are then electrically tested, impregnated in insulating varnish and baked. Finally the stators are returned by road to Huddersfield for assembly. The Barnsley factory also houses the motor control gear department which has been transferred from Huddersfield.

Electronically Controlled Production Lines

Stator winding at Barnsley is carried out in conjunction with an electronically controlled conveyor system which was devised and made by the company's electronics and production planning departments to eliminate, as far as possible, manual handling and operatives' waiting time. As we saw when we visited the works on the day of the formal opening, the whole of the production takes place on three parallel conveyor lines and provision is made for the addition, when required, of two more conveyor lines in parallel with the existing lines. Each of the winding conveyors has working stations for thirty-seven stator winders. As can be seen from Fig. 2, the working stations are equally disposed along the two sides of each conveyor. The winding conveyor consists of an upper belt which brings the work to the winders and a lower belt which takes the work on to the next process ; the novelty of the

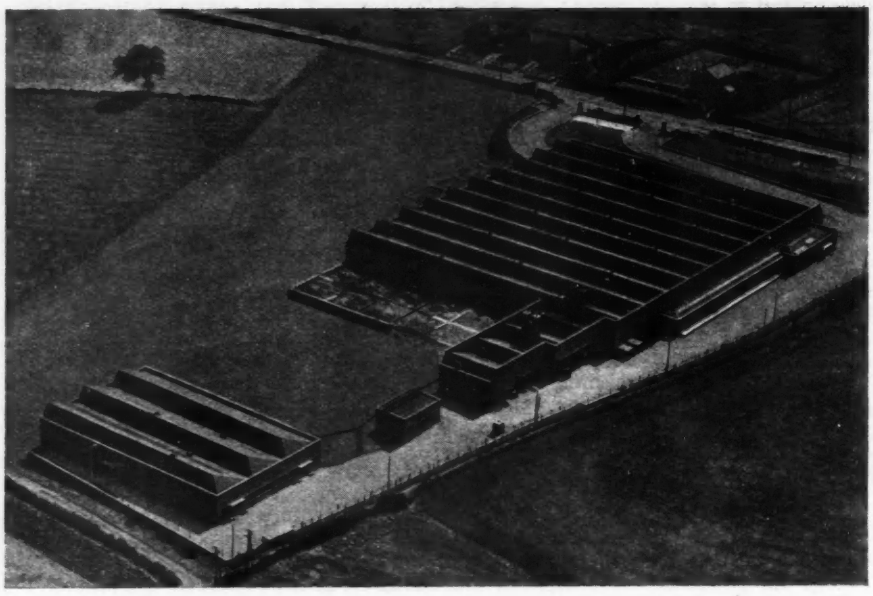


Fig. 1—Barugh Green Factory. Foundation raft with 30ft centres can be seen for two new bays under construction. The works canteen is on the left

system lies in the method of feeding the work individually to each operator, as required.

At each winding station there is a spring-loaded table on one side of the operator (Figs. 2 and 3) and an electric switch operated by this table is connected to a red indicator light on a central panel (Fig. 4) in the production control office which is responsible for maintaining a supply of materials to all the winders. The object of the system is to ensure that while each winder is working on a job she has all the materials for the next job in the reserve position on the spring-loaded table. In Fig. 2 the girl in the foreground has an unwound stator and a tray containing all the necessary coils, slot insulation and terminal block, &c., on the spring-loaded table. On the stationary conveyor belt opposite to the station occupied by the next girl a stator and tray of materials are waiting to be moved manually down the sloping ramp on to the spring-loaded table.

Briefly, the operation of the system is as follows. When an operator (for example, winder No. 7 on conveyor No. 3) has finished winding a stator she swings the manipulator frame into the unloading position, unlocks the stator and slides it on to the lower conveyor which carries the job to the next process. The girl then swings the frame to the loading position and slides the reserve stator into place from the spring-loaded table. The action of unloading this table switches on a red lamp in the appropriate position on the control panel (Fig. 4) to indicate that a reserve stator is required on that particular station.

The girl on the control panel then selects a work ticket, writes on it the conveyor and winder number and passes the ticket to the adjoining stator stock department. Here the appropriate stator is taken from stock and placed, with its work ticket, on the primary conveyor. A tray containing the necessary winding materials is placed alongside the stator. In the meantime the girl at the control panel will have pressed a button to light a green lamp alongside the red one, indicating that a reserve job is on the way to the winder No. 7, conveyor No. 3.

After leaving the stator stock department the complete set of parts on the conveyor arrives at a central indexing station, where it is diverted manually on to the feed section of conveyor No. 3. Here a selector switch controlling No. 3 conveyor is set to "Station No. 7." Then the stator is pushed from the feed section on to No. 3 conveyor itself. As this is done the stator interrupts a beam falling on a photo-electric cell and thereby starts a time switch. After a time interval corresponding to the setting of the selector switch the conveyor motor is stopped and the conveyor belt comes to rest with the stator and tray of parts facing the winder at station No. 7. The operation of bringing the stator to the required station is essentially one of running a constant speed conveyor for an accurately timed interval during which the work will have travelled the exact distance from the conveyor feed point to the station, in this instance No. 7.

Here the girl slides the stator and the tray from the stationary belt on to the spring-loaded table; until this has been done the conveyor cannot be restarted. The action of unloading the parts on to the table frees the conveyor and extinguishes the lights on the control panel to indicate that the reserve work has reached its destination. At the same time a red light on the selector switch controlling No. 3 conveyor at the central indexing station is extinguished to show that that conveyor is again free to carry work to the next station that needs it.

Beyond the stator winding sections of each conveyor there is a line of connector stations where the end connections of the winding are completed. When the winder slides her finished work on to the lower conveyor it is taken towards the connector stations and up a small ramp conveyor (Fig. 5) until it reaches a photocell which stops the conveyor until any one of the connector stations requires a stator. The conveyor feeding the connector stations, like the winder conveyor, is controlled by the operation of spring-loaded reserve work tables, a photocell and a timing counter; but, unlike the winder conveyor, its operation is automatic. A selector switch of the kind used in automatic telephony is continually "sweeping" to check the condition of each of the connector stations. When any of the spring-loaded tables is unloaded the conveyor is started, the stator at the top of the ramp is fed on to the horizontal section of the conveyor, the ramp section is stopped and the single stator is conveyed to the connector station from which the signal emanated. It is stopped at that station by the action of a timing disc which counts the number of stations that the stator has passed. The chain-driven counting disc with its photocell is on the extreme left of Fig. 5; next to it is a cabinet with the front cover removed to show the relays and rotary selector switch; at belt level can be seen the two photocells which (in conjunction with the spring-loaded tables) control the starting and stopping of the ramp and feed sections of the conveyor.

After the terminal boards have been fitted and the winding connections completed each stator is placed on a conveyor below the feed conveyor and is transferred thereby to a testing station. This final conveyor is push-button controlled by the tester required. At the testing station the stators are tested on a cathode-ray oscilloscope apparatus (Fig. 6) which has been developed by the company's electronics department for the quick detection of winding faults, including phase balance and reversed coils. Each stator is then flash tested in accordance with the relevant British Standard. The physical dimensions of the winding over the end connections are also checked to ensure that they will be accommodated within the end shields of the motor. After testing each stator is raised by a pneumatic lift and loaded on an overhead conveyor.

Each of the existing three belt conveyor lines, therefore, consists of a winding section followed in turn by a connector section and a testing station. After being tested the output from the

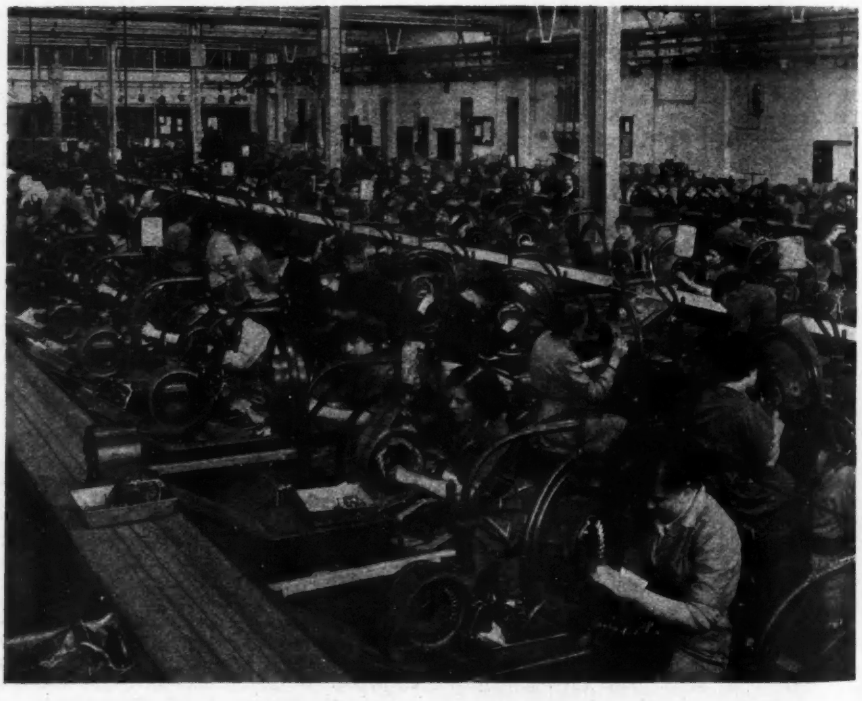


Fig. 2—Conveyor lines whereby work distribution to a total of 185 stator winders can be controlled by one girl at the panel shown in Fig. 4. Three conveyor lines are now in operation and there is provision for two more

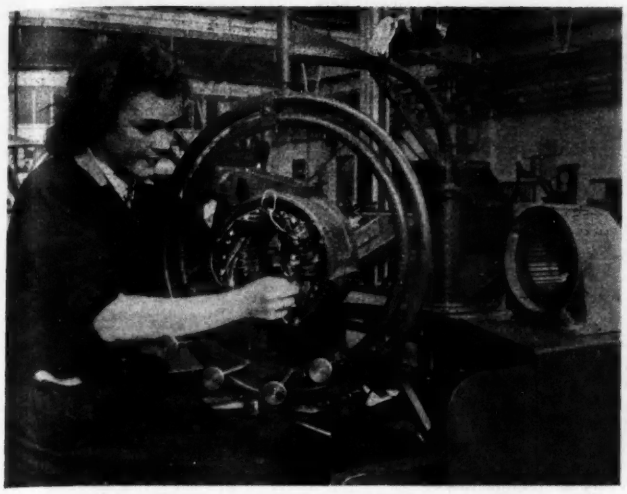


Fig. 3—One of the winding benches showing the tubular frame in which the stator can easily be manipulated for loading, winding and unloading

Fig. 4—Conveyor control panel for meeting the material requirements of 185 stator winders at the Barugh Green Factory

three lines is handled by a single continuous overhead conveyor system which can be seen in the background of Fig. 2. This conveyor carries the stators to the oven enclosure (to the right of Fig. 2). Here the stators are unloaded from the overhead conveyor by means of a pneumatic lifter platform; terminal boxes, covers and earth screws are fitted and spigot lacquer is applied. The stators are then loaded on a continuous-flight bar conveyor oven for impregnating with varnish and baking, after which the stators are fettled, painted in modern water-wash paint booths and finally inspected, ready for dispatch by road to the Huddersfield works where the final assembly of the motor is carried out.

The system we have described has been devised to provide the maximum flexibility in the distribution of work involving some thirty types of stator, 500 different variations of winding and voltage, combined with ten alternative speeds. Allowance can be made for variations in the winding skill of operators and work can be allocated according to the ability of each operator. The central control point enables suitable work to be selected with a minimum of effort, the illuminated control panel provides confirmation that the right job has reached the person for whom it was intended. Operation is completely controlled by one girl, with the assistance of a controller at the central indexing station.

The installation of the conveyor system has released for other duties six girls from the winding department who formerly distributed coils to the winders from the preforming section. Two people have been transferred from the stator department leaving only one man on this work, and six labourers who were formerly needed to transport work and lift it in and out of the winding frames have been released for other work. It is estimated that production overheads have been reduced by 20 per cent at the new factory by this method. About 300 stators per day are wound in the new factory.

A similar conveyor system for the assembly of motor control gear is being brought into operation in the Barugh Green factory, the object being to provide a controlled flow of components at each of a number of work benches flanking the conveyor. Approximately 250 items of control gear of various kinds are produced every day.

The Factory Building

The building has been designed to allow for the vacant part of the site, as shown on the aerial photograph (Fig. 1) to be covered with factory space; to provide for this development all the lavatories, welfare rooms, boiler house, workshops and the substation and access roadways have been located to the west of the site.

All permanent walls are load-bearing brick and the roof is constructed of welded north-light portal frames on stanchions which form 30ft square bays to give flexibility of production layout. The roof is covered with green mineral finish insulated steel decking to the south slope and patent glazing to the north light.

As Barnsley is a coal mining area and may be subject to subsidence the building is supported

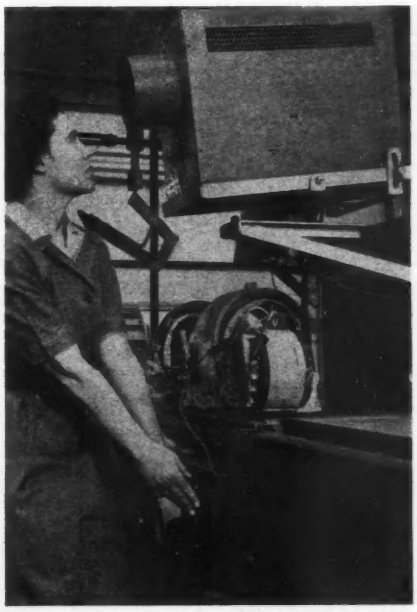


Fig. 6—Cathode-ray test apparatus for detecting winding faults including phase balance and reversed coils. After flash testing the stators are raised by pneumatic lift and loaded on the conveyor in the background

on a number of reinforced concrete rafts in the form of beams under the floor to the same 30ft square as the grid of the stanchions. These beams are laid under the floor and are 3ft deep, 3ft wide at the top and 1ft wide at the bottom; the plan form of these can be seen (Fig. 1) in an extension that is now being built in the centre of the site. Each raft being separated from the other by a flexible joint, the factory area is, in effect, sub-divided to minimise the damage in case of subsidence. The floors are of reinforced concrete slabs covered with asphalt. The side walls, where the factory is to be extended, are brick panels set in the steel frame to facilitate removal when necessary.

The canteen, which has seating capacity for 600, is built to the extreme north of the site and is of similar construction to the main factory, so that it can be used as production space if required.

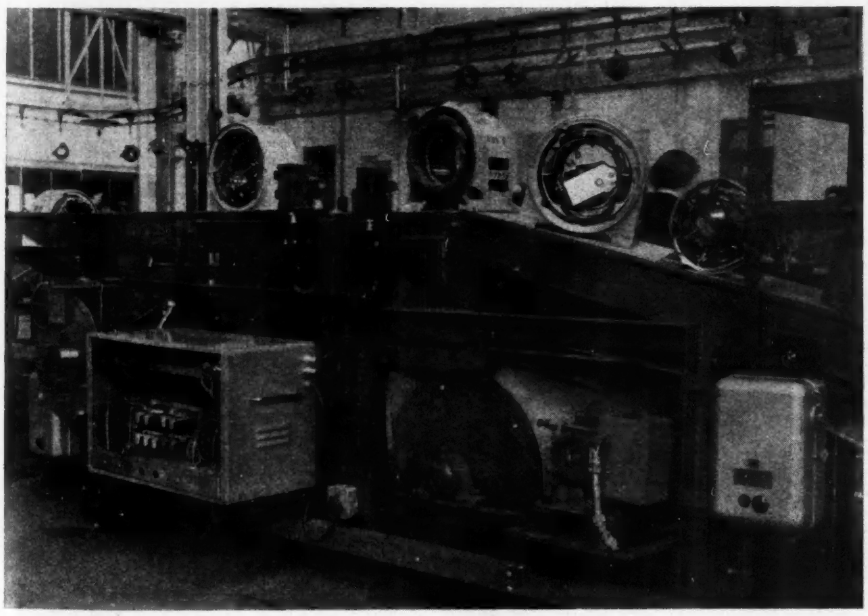


Fig. 5—Automatic counting mechanism controlling a conveyor feeding the winding connector stations. The counting disc and photocell are on the left, next to the cabinet containing the relays and selector

British Railways Standard Class "8" Locomotives

The new standard class "8" 4–6–2 locomotives for British Railways have a tractive effort of 39,080 lb and incorporate certain points in design not hitherto applied to standard locomotives. The engine and tender are carried on roller bearing axleboxes throughout, and steam distribution is by means of Caprotti valve gear.

PARTICULARS have now been issued of the new standard class "8," 4–6–2 locomotives for British Railways, built at the Crewe works of the London Midland Region. The first of these locomotives, which were designed in detail at Derby, is No. 71000, the "Duke of Gloucester," illustrated on this page. Its leading dimensions are given in the accompanying table and the diagram we reproduce.

The boiler is of normal design with a working pressure of 250 lb per square inch, and is similar to that fitted to the class "7" locomotives. A multi-valve regulator is incorporated in the superheater header fitted in the smokebox and has a connection, controlled by the pilot valve, for supplying steam to return the Caprotti valves to their seats. The "Belpaire" firebox has its front extended into the boiler barrel to form a combustion chamber, and is just over 8ft long outside with a width tapering from 7ft 9in at the front to 7ft 4in at the back.

The rocking grate provided has fourteen rocking sections, seven on each side of the centre line, and each section carries fourteen renewable firebars. The two sides of the grate can be rocked independently from the footplate, full rocking travel being used to drop the fire over an ashpit, and a shorter travel for agitating the fire to eliminate ash and break up clinker whilst running. A self-emptying ashpan has three hoppers, one between and one outside of each of the frames, the bottom flap doors on the hoppers being connected by a shaft for operation by levers from ground level. Front damper doors on each hopper and a back damper door on the central hopper are operated through a handwheel and screw gear to give fine adjustment of the air opening.

A cylindrical smokebox rests on a saddle which is cast integral with the inside cylinder and the inside slidebar carriers. Each of the twin blast pipes has a plain circular cap 4in diameter, and is fitted with a blower ring.

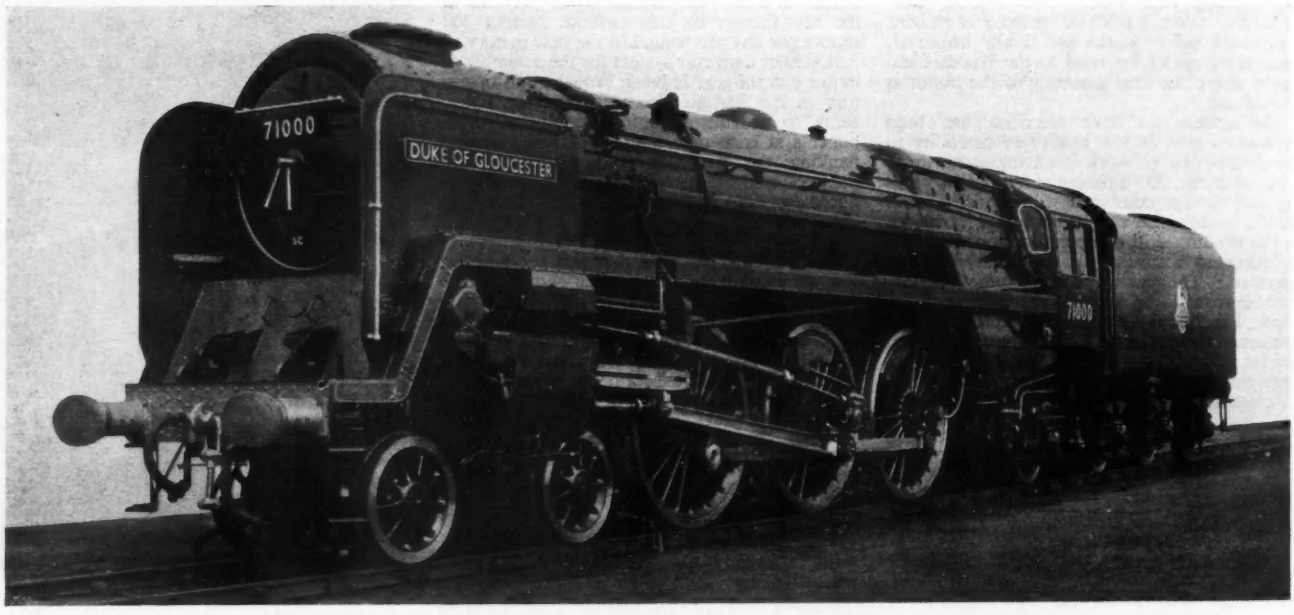
The main frames are 1¼in thick steel plates spaced 3ft 2½in apart with the centre lines coinciding with the centre of the axlebox guide faces. The axlebox guides are welded integrally with frame plates and are fitted with manganese steel liners. The frames are well braced by vertical and horizontal stretchers. Two of the vertical stretchers support the front of the boiler barrel and the firebox throat plate on brass wearing liners, whilst the back of the firebox is carried on brackets on the rear extension frames. A rear end frame extension consists of two 2in thick slabs riveted to the main plates behind the trailing coupled wheels and carrying a cast steel dragbox at the hind end.

Leading Particulars of Class "8" Standard Locomotive

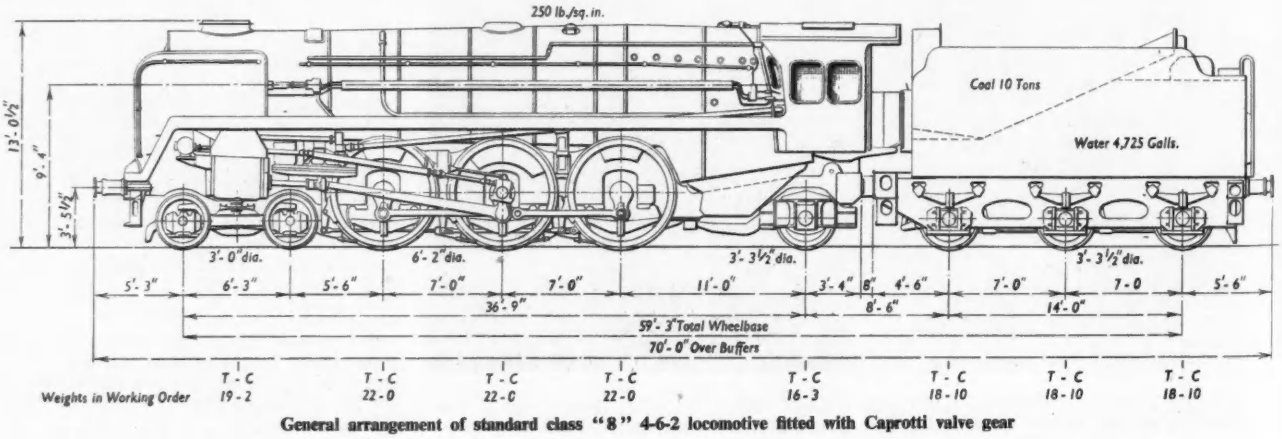
Cylinders (three)	18in by 28in
Wheels :	
Coupled, diameter	6ft 2in
Bogie, diameter	3ft
Pony truck, diameter	3ft 3½in
Wheelbase coupled	14ft
Wheelbase, engine and tender	59ft 3in
Heating surface :	
Tubes	2264 sq. ft
Firebox	226 sq. ft
Total evaporative	2490 sq. ft
Superheater	691 sq. ft
Grate area	48·6 sq. ft
Boiler pressure	250lb per sq. in
Tractive effort	39,080 lb
Adhesion factor	3·78
Weight of engine in working order	105 tons 5 cwt
Weight of engine and tender in working order	156 tons 15 cwt

The engine and tender are carried on Timken roller bearing axleboxes throughout, those for the bogie and intermediate and trailing coupled axles being of the non-split cannon design.

Underhung spring brackets integral with the horizontal frame stretcher and fitted with rubber damping pads and hangers in tension are provided for the laminated coupled axle springs, which have a span of 4ft when loaded. The solid hangers are slotted at each end to take



Standard class "8" 4-6-2 locomotive fitted with Caprotti valve gear and having a tractive effort of 39,080 lb



General arrangement of standard class "8" 4-6-2 locomotive fitted with Caprotti valve gear

cotters, adjustment of the springs being obtained by fitting cotters of suitable depths.

The three cylinders are steel castings with cast iron liners for the cylinder barrels, and the inside cylinder, which drives on the leading coupled axle, is located forward of the two outside cylinders, which drive on the intermediate coupled axle.

Steam distribution is by means of British Caprotti valve gear in which separate inlet and exhaust poppet valves at each end of the cylinder are actuated by rotary cams. The drive for the camboxes on the outside cylinders is taken from the intermediate coupled wheels by means of worm gearboxes mounted on "return cranks." Tubular shafts transmit the drive from the gearboxes to the camboxes. The drive for the inside cambox, situated in an accessible position in front of the smokebox saddle, is taken from an extension on the wormshaft on the left-hand cambox through a right-angle bevel gearbox.

This engine has an "end-on" reversing wheel in the cab with a transmission tube to a worm reversing gearbox on the left-hand side of the engine. Two cross shafts with flexible couplings connect across the engine to two other worm reversing gearboxes. From each of the three reversing gearboxes there is a transmission tube with a flange coupling at the rear and a spline coupling at the front to each respective cambox. Reversing the engine is done by advancing or retarding the angular position of the cams relative to the camshafts and any cut-off desired is obtained by the angular adjustment of the inlet cams in relation to each other.

Cylinder lubrication is by means of mechanical lubricator through atomisers which mix saturated steam with the oil prior to entering the cylinders. The atomisers are controlled by steam taken from the cylinder cock actuating valve, and when the cylinder cocks are closed the actuating valve is open and supplies steam to the atomisers. Conversely, when the cylinder cocks are open the actuating valve is closed and no steam is supplied to the atomisers.

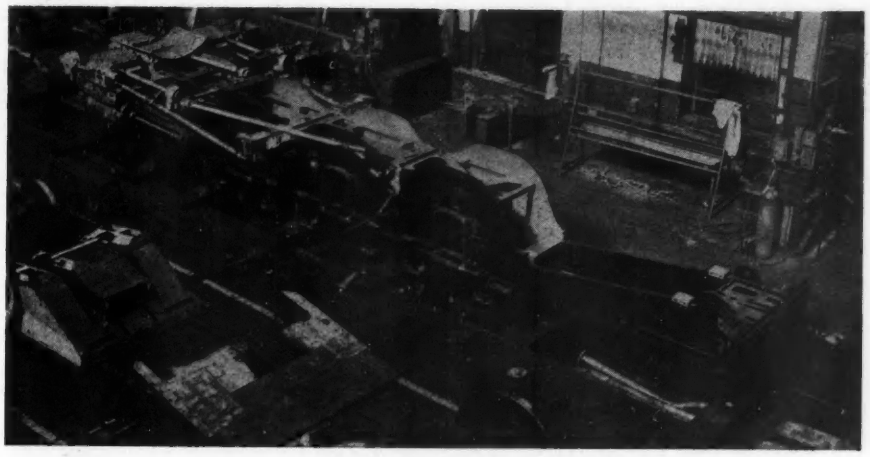
The cylinder lubricator also supplies oil to the piston-rod packings, whilst a second lubricator supplies oil to the slidebars. Both of these lubricators are driven from the outside camboxes of the valve gear. Grease lubrication is provided for the axlebox guides, brake shaft bearings, firebox supports, bogie bolsters, pony truck pivot pin and pivot face.

A method, new to British Railways, has been introduced for locking the big-end cotter on the inside connecting-rod. In it a special serrated locking plate has serrations phased on both sides of the plate in such a manner that four different positions of the serrations relative to the serrations on the back edge of the big-end cotter can be obtained. This locking arrangement allows an adjustment of $\frac{1}{32}$in in the cotter position and as the taper on the cotter is 1 in 16 a final adjustment of approximately 0·002in on the big-end bearing is obtained.

On the four-wheeled bogie the engine weight is carried by side bolster pads and laminated springs fitted in compensating beams, whilst side play is controlled by double helical springs. On the pony truck the engine weight is taken at three points on the frame, one point being at the pivot centre of the truck, and the other two at sliding bolster pads on the frame behind the centre line of the pony truck axle. Helical main bearing and side play control springs are fitted.

The cab structure is carried by cantilever supports hinged to the firebox backplate and by a diaphragm plate at the drag box, this arrangement allowing full freedom for the cab to move with the boiler as expansion takes place. All boiler fittings and pipes are kept free from the main frames to avoid differential expansion, and the exhaust injector on the right-hand side and the live steam injector on the left are carried on brackets attached to the ashpan and foundation ring.

The tender, which has water and coal capacities of 4725 gallons and 10 tons respectively, has a steam-operated coal pusher and coal sprinkler gear. The engine and tender have steam brakes which can be worked in conjunction with the vacuum brake or independently by means of a separate driver's valve. Single brake blocks are fitted to the six coupled wheels and all tender wheels.



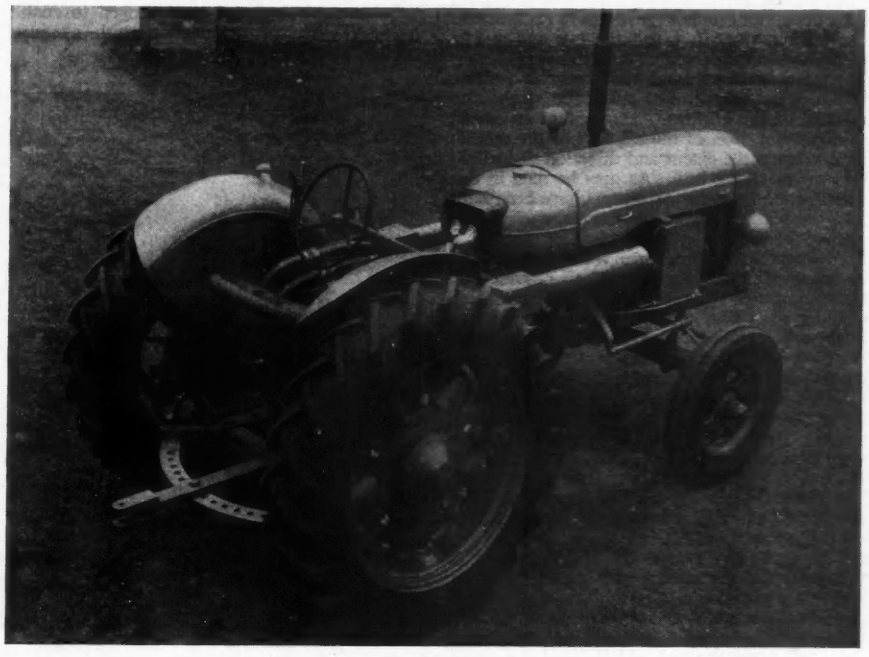
Locomotive under erection showing arrangement of main frame members. The left-hand Caprotti valve gear can be seen with the worm reversing gearbox connections

National Institute of Agricultural Engineering

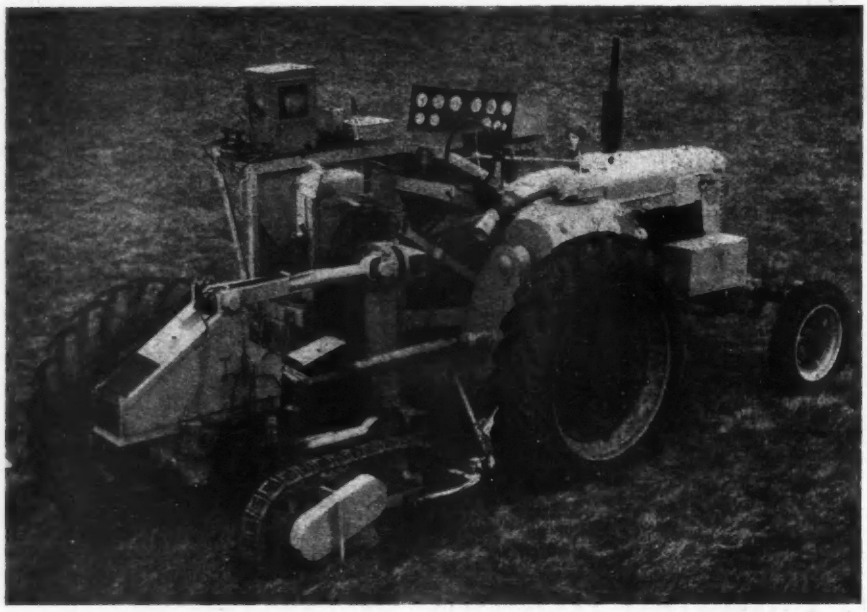
ON Wednesday and Thursday of last week, visitors from this country and from overseas were able to see something of the varied research and development work which is in progress at the National Institute of Agricultural Engineering, Wrest Park, Silsoe, Bedfordshire. The work of the Institute began, at Oxford, as a department of the university, as long ago as 1924. In 1942, the Institute became part of the Ministry of Agriculture and was moved to temporary quarters at Askham Bryan, Yorkshire, its principal functions there being to give technical advice on agricultural machinery and to train machinery instructors who were attached to County War Agricultural Executive Committees.

At the end of the war, there were some organisational changes by which the National Institute of Agricultural Engineering became a State-aided body under the control of the Agricultural Research Council, and administered by the British Society for Research in Agricultural Machinery. The move to the present permanent quarters at Wrest Park was made in 1947. The scope of the research and development work there covers all aspects of agricultural and horticultural mechanisation, with the exception of dairying and poultry husbandry, and the director of the Institute is Mr. W. H. Cashmore. The nature of the work undertaken has been described at different times in these columns, notably in a paper which Mr. Cashmore presented to the Institution of British Agricultural Engineers, and which was reprinted in our issue of February 27, 1953, and also in an article dealing with some of the apparatus designed at the Institute for machinery testing which Mr. H. J. Hamblin contributed to our issue of August 3, 1951. The Institute arranges its "open days" at two-yearly intervals, in order to demonstrate the progress made with the work undertaken in the nine departments.

Last week, the development which attracted possibly more attention than any other was the work which is being done on hydraulic transmission for farm tractors. This project, like



Experimental tractor with hydraulic transmission. The equipment includes a variable delivery pump and hydraulic motors built into the driving wheels



Single wheel tester for research into tractor wheel efficiency. The wheel on test is shown on the left

many others at Wrest Park, is essentially a long-term one, and is being undertaken in the mechanical engineering department, of which Mr. H. J. Hamblin is the head. Some time ago a hydraulic motor fitting inside a 9–32 pneumatic-tyred wheel was built for experimental purposes. With it, peak efficiencies in the region of 90 per cent were obtained, and it was felt that if a wheel motor cou d be developed to reach an efficiency of 92 per cent, the overall efficiency of the hydrostatic transmission might reach as high a figure as 87 per cent. These earlier experiments indicated that the system was satisfactory from the point of view of efficiency, and consideration was then given to the design of an experimental tractor. It was decided that the best course was to take a medium-powered tractor and to convert it to hydraulic transmission with the minimum of incidental alteration. As shown in the illustration on page 819 the Institute has used a Fordson " New Major " tractor and has converted it to a hydraulically propelled unit.

The equipment which has been incorporated in this experimental tractor consists of a variable displacement pump, driven by the tractor engine, which supplies oil under pressure to each of two hydraulic motors in which the pressure energy of the oil is converted into mechanical power. The pump is an axial-piston design with a tilting box to effect variation of the piston stroke and reversal of the oil flow. At constant speed the rate and direction of the oil flow to the motors depend upon the extent and direction of inclination of the tilting box. As may be seen in our illustration, the hydraulic motors have been built into the rear wheels of the tractor, each motor having five radial cylinders rotating around a fixed eccentric, the direction of rotation depending on the direction of the flow of oil provided by the pump. A pipe which leads from each cylinder to a port on a plate valve serves the dual purpose of admitting oil to and exhausting oil from the cylinder. An auxiliary hydraulic circuit automatically supplies replenishment oil to the low-pressure side of the main circuit to make good any slip oil losses in the motors and pump. This auxiliary circuit consists of a small vane pump, mounted on the end of the engine crankshaft, which draws oil from a reservoir. The oil then passes through a filter to a directional control valve which automatically passes enough oil for replenishing the low-pressure side of the main circuit, any surplus oil being returned to the reservoir through a pressure-relief valve. On this experimental tractor, the conventional clutch control and gear lever have been replaced by a single lever giving a stepless speed control from full speed forward to full speed in reverse. So far, no field tests have been made with the tractor and it is realised that a considerable amount of further experimental and development work will have to be done. One of the advantages claimed for the arrangement of a hydraulic pump adjacent to the engine and hydraulic motors built inside the driving wheels is that there is much more space available for mounting implements. Furthermore, the method of control is such that damage by unskilled tractor drivers is less likely than with a conventional clutch and gear transmission.

Another item of research in progress in the mechanical engineering department is concerned with tractor wheel efficiency. A single-wheel tester has been devised, the instrumentation of which includes a direct-reading slip meter consisting of a ratio meter fed from two tachometer generators driven by the wheel under test and a towed track unit. The arrangement of the equipment is illustrated herewith.

In the soil department, of which Mr. J. C. Hawkins is the head, recent work has included the development of a complete potato harvester and grader, and also a tractor-mounted ditch-cleaning machine. This latter machine has been designed at the Institute for maintaining ditches up to 4ft 6in wide and 3ft deep ; it consists of a power-driven shaft which projects from the side of the tractor, and which is adjustable for speed, height and angle. To this shaft there is attached a simple form of cutter which cleans out the ditch and scatters the spoil on the bank.

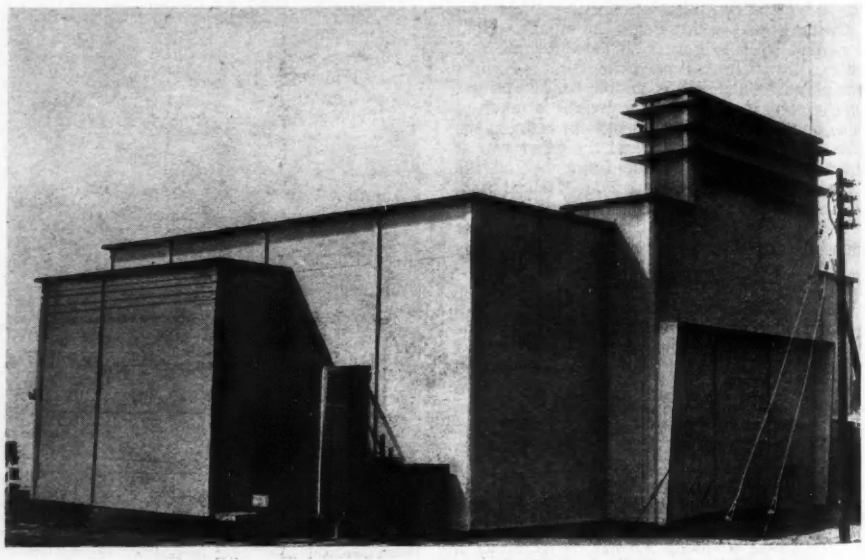
Some interesting examples of the work of the Institute's instrumentation department—of which Mr. H. H. Taylour is the head—were shown during the open days. They included the examination of discrepancies between the analysis of freeze-dried and heat-dried grass in connection with tests of grass driers. Work has also proceeded on the design of a suitable tractor-mounted machine for stripping the fibrous bark from stems of jute and jute substitute crops. This machine was developed, at the request of the Colonial Office, following a visit to British Guiana two years ago by a member of the department's staff to witness trials of machinery for harvesting stem fibre crops. Another machine which has been developed at the Institute for overseas agriculture is a ground nut harvester, capable of digging the plants and stripping the nuts from them in a single operation.

Power House for Agricultural Show

TO provide exhibitors at the Bath and West Agricultural Show at Exeter with an independent supply of electricity a power-house consisting of three 400kW diesel generating sets has been installed on the grounds. It provides also for a piped hot water supply.

They are housed in the transportable building shown in our illustration, which has a prefabricated steel frame with timber panelling faced with fibre glass and perforated hardboard. A balcony within has been arranged to enable visitors to see in conjunction with a mural exhibition the whole process of electricity generation.

The power plant consists of three 400kW diesel alternator sets supplied by R. A. Lister and Co., Ltd., the total output available, therefore, for the supply of light, heat and power throughout the 80 acres of show grounds being 1200kW. Each set comprises a Blackstone " ERS8 " diesel engine direct coupled to an E.C.C., 500kVA, 0·8 p.f., 3 phase, 420/240V, 50 c/s 4-wire alternator with frame mounted exciter, vee-belt driven from the alternator



The power house at the Bath and West Show equipped with three 400kW diesel generating sets to provide an independent supply of electricity throughout the Show

shaft. The alternators and switchboards were supplied by the Electric Construction Company, Ltd.

The Blackstone engine has an output of 600 b.h.p. at 750 r.p.m. and is fitted with a Napier turbo-charger. Compressed air starting is employed direct on all cylinders. The installation includes a Broom and Wade "N4" motor-driven compressor, and an engine-driven "N2" compressor with a Lister 6/1 engine.

With their bed-plates the three engines and generators weigh more than 48 tons. The three sets are carried on a common foundation consisting of a steel under framework laid direct in the ground.

The switchboard equipment consists of three E.C.C. alternator control panels, two feeder panels, a synchronising panel and a distribution panel. The automatic voltage regulator on each alternator panel controls the voltage within 2½ per cent. Remote operated governors are fitted to the engines and operated by push-button switches on the control panels. Frequency control is obtained with an electrically-operated master clock and frequency meters.

A matter of particular interest about the plant is the use of waste heat from the engine for the supply of hot water to certain sections of the Show grounds. The engines are provided with radiators for cooling the engine water but, in addition, each is fitted with a heat exchanger and a Drayton regulator valve. The cold water supply to the power-house is fed from the city mains and passes through the engine heat recovery unit situated in the engine exhaust piping. From that point the hot water is taken to two 1000 gallon insulated tanks inside the building.

While this system is in operation the engine cooling water is fed into the heat exchanger, but when hot water is not being used from the storage tanks the regulator valve comes into operation and diverts this cooling water through the radiator. The radiator also has a lubricating oil cooling section incorporated.

The heat recovered from the jacket water and from the exhaust gases is approximately equivalent to the heat value of the electrical power generated by the alternator, giving an overall thermal efficiency, under full-load conditions, approaching 70 per cent.

The hot water from the storage tanks is pumped round a reinforced rubber ring main laid in the centre of the Show ground.

Newcomen Society's Summer Meeting

LAST week, the Newcomen Society for the Study of the History of Engineering and Technology held its summer meeting in Cornwall, making Falmouth the headquarters for the occasion. There were forty-five members of the Society at the meeting and many of them had assembled at the Falmouth Hotel by the early evening of Wednesday of last week. There were, however, some very late arrivals, as, owing to a reduction in the train service on account of the unofficial strike in the Western Region, a party of members from London made the journey by motor coach. That journey was a pleasant and interesting one even though it occupied the whole of the day and much more of the evening than had been anticipated !

It has been said many a time that no summer meeting programme of the Newcomen Society would be complete if it did not include the inspection of a beam engine. Last week, of course, there were several of these engines for the members to see and admire, their admiration being coupled with earnest hopes for the continuing success of the efforts being made by the Cornish Engines Preservation Society to save from destruction some excellent examples of the work of distinguished Cornish engineers. During their visits, the members of the Newcomen Society were joined by the chairman of the Cornish Engines Preservation Society, Mr. A. Treve Holman, M.I.Mech.E.; the honorary secretary, Mr. W. Tregoning Hooper, and the honorary curator, Mr. J. H. Trounson, whose lucid explanations and answers to questions added much to the interest of the visits. Early on Thursday morning, the party set out for East Pool, making a brief stop on the way at Cross Street, Redruth, to visit the house in which Murdoch lived and carried out his experiments in making coal gas. At Taylor's Shaft, East Pool there is the 90in beam pumping engine which was built by Harvey and Co., of Hayle, in 1892, and was originally erected at the Highburrow East Shaft of the Carn Brea mines. The engine was re-erected on its present site thirty years ago, and is the first to be acquired by the Cornish Engines Preservation Society. The East Pool engine has a beam 33ft 3in long, the indoor end being 1ft 9in longer than the outdoor end. The stroke is 10ft in the cylinder and 9ft in the shaft and the horsepower is 425. It has been stated that this engine was exceptionally heavily constructed for a Cornish engine of its cylinder diameter. In a paper read by the designer in 1893, the following figures were given :— Engine weight, 125 tons ; boilers and fittings, 65 tons ; strapping plates and glands, 39 tons ; the beam, 52 tons ; iron pump rods, 89 tons ; plunger pumps and pump chambers, 272 tons ; balance bobs, 45 tons, which figures add up to a total weight of 687 tons.

Outside the East Pool engine-house last Thursday, there was arranged an "exhibit" not included in the Newcomen Society's official programme. This was the "Gladiator," a 7 h.p. showman's locomotive built by Charles Burrell and Sons, Ltd., at Thetford, in 1909. The "Gladiator" was retired from showground service at the beginning of the war in 1939, and for several years thereafter was laid up at Exeter. Last year, however, the engine was driven under its own steam from Exeter to Redruth, about 100 miles, where its renovation and preservation have been undertaken by the Gladiator Club. The Newcomen Society's next call was at Robinson's Shaft, at the South Crofty mine, where an 80in beam pumping engine is now completing a century of active service. This engine was built in 1854 by Sandys, Vivian and Co., of Copperhouse, to the design of Captain Samuel Grose. It was first erected at Wheal Alfred mine, near Hayle, and was subsequently moved to Crenver and Wheal Abraham, near Crowan. Later, the engine was again moved to Tregurtha Downs mine, near Marazion, where it worked for several years, and in 1903 it was transferred to its present site at South Crofty. There it has been operating day and night ever since, though in the near future it is to be replaced by electrically-driven pumps. The horsepower of the Robinson's engine is given as 335 at full load. The engine has an equal ended beam, the stroke in the shaft and in the cylinder being 10ft 4in. There are three sizes of plunger hole pumps in the shaft, with diameters of 15in, 14in and 10in respectively, water being raised from a total depth of 2021ft.

The first visit on Thursday afternoon was to the cottage at Penponds, near Camborne, where Richard Trevithick lived for many years. This cottage has been acquired by the Cornish Engines Preservation Society and fully restored, and last September a plaque recording Trevithick's residence there was unveiled by his great-grandson, Captin R. E. Trevithick. In one of the rooms some Trevithick relics are preserved. They include a print of Trevithick's projected tower to commemorate the passing of the Reform Act. He called it "a design for a gilded national monument of cast iron 1000ft high and 100ft diameter at the base." It was a project that did not materialise. Later on Thursday afternoon, the company assembled at Trevithick's memorial statue, in Camborne, upon which the president of the Newcomen Society, Mr. Rex Wailes, placed a chaplet. In a brief speech, Mr. Wailes recalled that the Society's last official visit to the district was made in 1933, the year in which the centenary of Trevithick's death was observed, and the occasion on which the memorial was unveiled Mr. Wailes recalled also the eulogy upon the life of Trevithick which was delivered in the same year by the late Mr. Loughnan Pendred, who was the president of the Newcomen Society at the time

After this brief ceremony, the Holman Museum, in Camborne, was visited. This museum presents not only the history of the firm of Holman Bros., Ltd., but contains many other interesting items associated with the Cornish mining industry. In it there is preserved a 22in rotative engine from Rostowrack Clayworks, which was built, in 1851, by West and Son, of St. Blazey. Lord Falmouth, president of the Cornish Engines Preservation Society, presented the engine to the Society last year, a few months after it had ceased work at Rostowrack. Another interesting exhibit in the museum is a working model of a "man engine." This model was made and presented by Mr. P. J. Packman, A.M.I. Mech.E., of Twyford, Berks. The man engine was not of Cornish origin. It was introduced in the early part of the nineteenth century, when concern was felt about the strain imposed by miners having to ascend to the surface by ladders. The Cornwall Polytechnic Society offered a money prize for the most successful method of overcoming the difficulty. The man engine, introduced by Herr Dorell and used in German mines, won the prize. The first man engine installed in Cornwall was at the Tresavean mine, near Redruth. In 1833, a Captain Puckey developed a single-rod man engine for Fowey Consols mine, and it was this design which was supplied to several other mines. Captain Puckey's "engine" consisted of a long timber rod running from top to bottom of the pit shaft ; this rod was moved up and down through a stroke of from 8ft to 12ft, the top end of the rod being coupled to a crank pin on a large gear wheel driven by a pinion on a steam engine. The movement of the rod, therefore, had a simple harmonic motion. On this rod were mounted platforms, about 24in square, at intervals equal to the stroke of the rod, and there were also fixed platforms secured to the sides of the pit shaft on either side of the moving rod, pitched at the same distance. Thus, when the main rod was working, miners were able to step from a "fixed platform" to a "rod platform," when the latter came to "rest" at the end of its stroke (the platforms then being level). The subsequent movement of the rod took the miner up or down by choice so that he could traverse the pit shaft with very little effort. These lifting devices ran at from three to six strokes a minute.

The Newcomen Society's annual dinner was held at Falmouth on Thursday evening, the guests including the Mayor and Mayoress of Falmouth. A toast to "The Guests" which was proposed by the president, Mr. Rex Wailes, was acknowledged, in a particularly pleasing speech, by Miss R. Beckett, the Borough librarian. Miss Beckett said that to-day it was often claimed that the world of art was most important so far as gracious living was concerned. It was, however, important to remember that engineers had contributed much to the art of gracious living. After dinner, a fascinating talk on Cornish mining history was given by Mr. A. K. Hamilton Jenkin, an acknowledged authority on the subject. At the end of the evening, Mr. W. Bardon, from Holland, on behalf of Koninklijk Instituut van Ingenieurs, presented a medal to Mr. A. Treve Holman, as an expression of appreciation from the Netherlands of the work being accomplished by the Cornish Engines Preservation Society. Mr. Bardon's remarks were cordially endorsed by Mr. E. S. Dean on behalf of the American Newcomen Society.

Last Friday's programme included a visit to the works of the Goonvean and Rostowrack China Clay Company, Ltd., a brief inspection at Lanivet of a set of water wheel driven stamps with wooden lifters, and an afternoon visit to Chyverton House, where the party was most hospitably entertained by Mr. and Mrs. Treve Holman. On Friday evening, members had the opportunity to see an excellent exhibition of books, drawings and prints on Cornish mining and engineering which was arranged at the Falmouth library by Miss Beckett, the Borough librarian. This event concluded another successful "Newcomen" summer meeting, the arrangements for which were, as usual, ably co-ordinated by Mr. A. S. Crosley, the Society's honorary secretary.

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SMOKE ABATEMENT

Much is known qualitatively about the harm air pollution causes; and the great "smog" disaster in central London in December, 1952, brought very firmly home, at least to Londoners, that the harm affects not only buildings and amenities but also human health. There is, too, plenty of evidence that the main culprit in smoke production is the domestic grate burning bituminous coal. But it is very far from the only culprit. Factory chimneys, power stations, locomotives, ships, iron and steel works, collieries, metallurgical and chemical works, cement works and many others pour smoke or fumes or both into the atmosphere. How and by whom smoke and fumes are produced is fairly well known. But visible smoke, it is becoming more clearly realised, is not the only nor even perhaps the more damaging of the air pollutants. Sulphur oxides, in particular, are important and it is possible that the harm they do is multiplied in some way when they are mixed with smoke and ash. All these are factors—there are many others—that the Government Committee on Air Pollution (the Beaver Committee) is no doubt taking into account in its present investigations, which, it is much to be hoped, will carry its work far beyond the limits of that survey of the present situation which was all it attempted in its first report issued last December. The National Smoke Abatement Society has now submitted a Memorandum to that Committee, the main heads of which are summarised on another page of this issue. We have no doubt, at all, that it will stimulate the thoughts of the Committee's members.

If a criticism may be ventured of the Society's Memorandum it is that there seems to be an undue optimism within the Society about the Government's willingness or ability to offer financial supports of one kind and another to smoke abatement; or to apply various restrictive measures. "Bearing in mind"—we quote from the Memorandum—"the heavy social cost of smoke there is a strong case for incentives (including that of quality) to popularise its (smokeless fuels) use in place of raw coal"; "the cost of the installation" of solid fuel burning domestic appliances of high standard of performance "should, if necessary, be borne by subsidy from the central Government" in certain areas including smokeless zones; "the Government should give financial aid for the development of the publicity and information services necessary to educate public opinion"; and "in the case of smaller authorities deterred by the cost of instruments and of the periodical analyses required" from co-operating with the Fuel Research Station in the investigation of air pollution "arrangements should be made for financial assistance from the central Government or County Council." Other suggestions have probably more hope of being acted upon. There is, for example, the proposal that a permanent committee might be set up to keep air pollution under review, rather in the way, no doubt, the London and Home Counties Traffic Advisory Committee keeps London's traffic needs under review. Again much more might be done by some local authorities, not so much through attempting to enforce the law, which is not in a very satisfactory state for enforcement, as through the education of the public in their areas. For that purpose—it is again a point made by the Society—the active participation of industrialists and industrial associations should be encouraged. The Society goes on to outline the form that new legislation might take. It may well be that the time is not yet ripe for the general application of laws preventing the emission from chimneys of smokes exceeding certain low standards of darkness; requiring local authorities to employ fully qualified smoke inspectors; laying down that all boiler and furnace firemen should possess a certificate of proficiency; prohibiting the installation of devices that cannot satisfactorily burn smokeless fuels; or requiring that plans and specifications of all new fuel-burning installations shall be submitted to local authorities for prior approval. Yet it must be admitted that without the application of some such laws air pollution is unlikely to be prevented; and that, unless such laws are enforced, during any winter in this country some disaster similar to that which afflicted London eighteen months ago may recur.

Unquestionably the main factor preventing the redrafting and firmer application of air pollution laws is the unreadiness of the public to accept the need for restriction. To the engineer, of course, it may seem a strange thing that factory owners are willing to let their chimneys smoke. For smoke emission implies inefficient combustion and waste of fuel. But boards of directors are interested in efficiency only in so far as it promotes economy; and it is easier for them to see how much more a trained stoker costs in wages, how expensive is the instrumentation necessary for efficient stoking, how dear is full and proper maintenance, and how much the replacement of outdated plant might cost, than to appreciate from figures of fuel consumption, which fluctuate widely with the weather and the activity of the plant, what savings accrue. Again, the ordinary householder is little interested at present in burning smokeless fuels because they are not easy to obtain and, even should he have a conscience about air pollution, he is likely to feel quixotic in using such fuels whilst all his neighbours cheerfully continue to pour smoke into the atmosphere. As the Beaver Committee put it in its first report, the causes and remedies of pollution by smoke are known. The problem of eradicating it is one of practicability and economics and of educating the whole community. The last of those factors seems to us the more important. For, once the bulk of industrialists and householders were convinced of the desirability of reducing pollution, objection to restrictive legislation would cease and firmer laws in favour of smoke abatement would be welcomed.

GUIDED MISSILE DEVELOPMENT

The missile for naval use now undergoing tests at Woomera is presumably the large guided anti-aircraft missile to which the First Lord referred recently as under development for fleet and convoy protection. Under our unimaginative security arrangements there is little likelihood of the results of these tests being made public. The British people are not encouraged to interest themselves in guided missiles, though many of our manufacturers are engaged in making components for them. Less than a year ago the Minister of Supply announced that no bomber could hope to outmanœuvre the guided rockets under development in this country, but there has been no official statement since then indicating that further experience confirms this optimistic forecast and that we have indeed found an effective counter to the high-speed, high-flying bomber armed with an atomic or hydrogen bomb. The trend of ministerial pronouncements has in fact been in the opposite direction. The Secretary of

State for Air—when pressing for his strategic bombers as a deterrent and retaliatory force—emphasised that we could not make ourselves impregnable against attack from the air. Other Service Ministers, while speaking in glowing terms of the capabilities of the guided missile, have always referred to it as a weapon which is unlikely to be in general use for some time.

A good deal of information on guided missile development is, however, available in the United States, where progress seems to have been much more rapid than in this country. Anti-aircraft guided rockets are now in quantity production for the United States Defence Department, and batteries for launching them are to be installed this summer in about a dozen strategic centres. Two squadrons of pilotless bombers are to be sent to Europe in the near future. Moreover, interest in guided missile development has been stimulated in the United States by giving names to the various types of missiles under test—whether successful or not—and by publicising their approximate weight, length, speed and their type—whether ground to air, air to air or air to ground. The anti-aircraft missile which seems to have given most satisfactory results under test is the "Nike," and it has been selected for use by the batteries now being installed. The Chief of Staff of the United States Army has in fact claimed that this missile can be relied on to bring down a bomber at over 60,000ft. It has a length of about 20ft and a diameter of 1ft. The propulsion unit uses liquid fuel, which, with the guidance units, occupies all the space available in the body of the missile. Fired from a launcher by a booster rocket which drops off early in flight, it has a range of over 35 miles and a speed in excess of 1000ft per second. The ground guidance unit, which takes over from the early-warning radar net, is based on the Command Guidance system. The system, which was under investigation by the Germans during the war, employs two tracking radars, one for the target aircraft and the other for the missile, commands being transmitted to the missile according to the impulses generated by moving a control rod. A self-homing device takes over in the latter stages of the attack. Whether its speed is sufficient to deal with the supersonic aircraft of the future seems doubtful, but used in conjunction with interceptor fighters, operating at longer ranges and armed with the new air-to-air missile "Falcon," the "Nike" should prove effective against any existing bombers.

We in Britain are inclined to hold conservative opinions of new inventions—whether for peaceful or warlike use—and it may well be that both the Minister of Supply and the United States authorities overestimate the capabilities of guided missiles. None the less, the progress made in their development since the war has been remarkable and there is some reason to believe that within a few years they may make the bombers' task impossible, particularly against our small country, whose radar defence net should be able to operate at 100 per cent efficiency. Indeed, if the jet bomber were the only danger, there might even be some room for complacency! But already winged missiles of the German V1 type—the United States turbo-jet "Matador" and "Regulus"—are available as long-distance carriers of explosives. These missiles have a range of from 400 to 500 miles and both can be launched from, and guided by, an aircraft or submarine. Moreover, the large supersonic rocket of the German V2 type has been the subject of much investigation and research in the United States, and there can be little doubt that before very long a solution will be found to the various technical difficulties at present associated with this kind of rocket. Engineers can usually find an answer to problems that are presented to them. But an anti-rocket missile demands a speed exceeding 4000 miles an hour and the devising of a system to guide it on to its target involves formidable difficulties. Certainly no such weapon exists to-day in prototype form. Probably it does not exist even on paper.

Literature

High-Voltage Laboratory Technique. By J. D. CRAGGS and J. M. MEEK. London: Butterworths Scientific Publications, Ltd., 88, Kingsway, W.C.2. Price 65s.

THE number of high-voltage laboratories in this country and, indeed, in all industrialised countries, has been steadily increasing over the past few decades, until to-day many of our universities and nearly all the larger manufacturers of heavy electrical equipment possess laboratories in which it is possible to generate potentials at least in the million-volt region. The reason for this growth is sufficiently obvious when one considers the continual increase in the quantity of electrical power consumed and the high working voltages associated particularly with its transmission, which this increase inevitably entails for reasons of economy. This, on the one hand, and the development of atomic physics, on the other, with its demand for high potentials for particle acceleration, mainly account for the existence to-day of well over a score of such laboratories in this country alone. Roughly one-third of these are in the universities and the book under review has been written largely for the research worker "beginning to use high-voltage equipment," who will in most cases be at a university. Nevertheless, it will be of use in industrial and other laboratories since, as stated by the authors in the preface there has hitherto been no work on this subject in English. The authors worked for many years in the high-voltage laboratory of Metropolitan-Vickers in Manchester and run a research school on gaseous breakdown at the University of Liverpool. The subject matter falls into two main groups—the generation of high voltages in various forms and their measurement. The first six chapters deal with the former, four more with the latter, and there is a further chapter dealing with miscellaneous apparatus.

Chapter I is on the generation of high-voltage direct current and deals with all the usual methods from valve and metal rectifiers to electrostatic generators of the Van de Graaf type. The question of ripple calculation and other problems are gone into in detail. The following chapter is devoted to the stabilisation of high-voltage direct current, and Chapter III deals with a.c. high-voltage generation at power frequencies and higher (resonance transformers, Tesla coils). Chapters IV and V are on the production of surges of high-voltage and heavy current respectively. In the former the construction and operation of impulse generators are described, and the mathematical analysis of various generator circuits is given; the very simple analysis that is adequate for nearly all the more usual applications could have been included here with advantage. In the chapter on heavy-current surge generators the authors depart from the main scheme by dealing mainly with the methods of measurement and the construction of heavy-current shunts, since the production of these surges is relatively straightforward. Chapter VI is devoted to the production of high-voltage square pulses, the need for which originated with the development of radar. Pulse-forming networks and many forms of modulator are described in considerable detail from the early rotary spark gaps to the trigatrons and gas-filled and hard-valve circuits developed later.

The remaining chapters deal with measurement apparatus and technique. Chapter VII is concerned with continuous voltages, both direct current and alternating current, and covers nearly all the known instruments used in this field, starting with a section on the various types of electrostatic voltmeter.

The use of sphere gaps is discussed in considerable detail and useful information is given particularly in relation to the question of irradiation. The uniform field gap between planar electrodes and rod-gap breakdown are also discussed, as are generating and electronic voltmeters. Finally, there is a section on the relatively new development of the use of specific nuclear reactions as a means of fixing a voltage scale. The next chapter is on impulse-voltage measurement and the greater part of it deals again with the sphere gap. The main characteristics of resistive and capacitative high-voltage dividers for direct current, alternating current, and impulses are dealt with in Chapter IX and the treatments by several workers are given of the inherent errors and distortions.

Chapter X, on high-speed oscillography, gives an account of many oscillographs of the recurrent surge and single-sweep type, dealing with sweep circuits for speeds in the ranges of microseconds down to milli-microseconds; it includes some very recent work. Both sealed-off and continuously evacuated forms of cathode-ray tube, with their rather differing techniques are dealt with, including, in the latter category, the micro-oscillograph developed for monitoring very fast transients in the milli-microsecond region. The final section is on the photography of the trace on a C.R.T. screen and provides some information on the sensitivities of various films and on the somewhat dubious matter of intensification. The last chapter, on miscellaneous h.v. apparatus, deals with various items, resistors, standard capacitors, mechanical rectifiers, which could all very appropriately have been included in previous chapters, with the exception of a few paragraphs on surge-protection devices, for whose inclusion in this work there seems to be little justification.

As the authors themselves state, most of the work described has already been published and is here assembled and abstracted. At times the book suffers from the lack of a sufficiently critical treatment of the very many different techniques and methods presented; they are in some sections described and even, on occasions, catalogued rather than discussed. This may be unavoidable in part, but in much of this work a multiplicity of overlapping methods exists and some guidance in their application would be welcome. However, it is clear that every endeavour has been made to omit nothing of significance and a very large number of sources are quoted or referred to.

Letter to the Editor

We do not hold ourselves responsible for the opinions of our correspondents)

UNIFIED SCREW THREADS

SIR,—The letter from Mr. Bryan B. Bateman, of Liverpool, published in your issue of May 14th, raised a number of fundamental issues and appeared to attack the whole policy of a unified screw thread. The issues raised can be summarised under two headings :—

(*a*) The principle of whether agreement with America on the screw thread should have been made at all ; and

(*b*) The details of the agreement which was in fact made.

Dealing first with (*a*), it is easy, now that the threat of war is possibly less imminent than it was some five or six years ago, to lose sight of the fundamental considerations which prompted the agreement. But it should be remembered that the concept of having a common standard for screw threads between this country and America was first suggested as a direct result of experience in the 1914–18 War. It is quite impossible to gauge accurately what the effect would have been in the 1939–45 War if that original concept had been followed through. Varying estimates have been made of the cost in time and equipment attributable to the absence of such agreement, and two of these estimates from authoritative quarters are worth recalling :—

" Lack of uniformity in screw threads alone is said to have cost the Allies a thousand million dollars, and when the Rolls-Royce " Merlin " engine was to be produced in America six vital months were lost while drawings were being translated into American practice. Many other equally startling examples have been given from time to time by responsible spokesmen."

Such considerations led those concerned in both countries to decide after the war that every effort should be made to arrive at common basic engineering standards, especially for screw threads.

While in times of peace it may be possible to differentiate between Service demands and those of industry, this division ceases to exist entirely in the engineering industries under conditions of war. The concept, therefore, that an agreement could be reached which would apply to the Services but not to industry generally would be failing entirely in its ultimate objective. Moreover, apart from war needs, common standards are becoming increasingly necessary if Britain is to maintain her place in the markets of the world.

In this connection it may be of value to quote the following extracts from a speech delivered in November, 1952, by Mr. William L. Batt immediately on his return to America after spending two years in this country as head of the organisation for administration of " Marshall Aid " :—

" We need to harmonise our national standards with those of our allies and friends. We have based much of our foreign policy on the effectiveness of the tremendous quantity of goods we are shipping abroad. . . . It is sheer folly to allow the small, dangerous differences to continue that confuse and delay the industrial production of the free nations. Where there is such common production, common interchange and common use, there obviously must be common standards for drawing procedure, screw threads, bolt and nut heads, preferred numbers, limits and fits, and other basic engineering practices."

Dealing now with (*b*), Mr. Bateman criticised a number of points of detail in connection with the Unified screw thread. Many of his points are matters of opinion and it is always easy to suggest after the event that those responsible for the negotiations should have taken some other course. Nevertheless, events of the last five years have amply confirmed the wisdom of the original concept of having a common standard for screw threads between this country, Canada and America, and indeed throughout the Commonwealth.

It is not altogether true, as Mr. Bateman suggested, that the same immediate result might have been achieved had this country simply adopted the American national thread without negotiation. British influence was mainly responsible for the fact that the agreed tolerances and allowances for the Unified thread are different from those of the American National thread, and are held by leading engineers to be technically superior and more suited to modern production methods than those in either of the earlier standards.

Mr. Bateman's case also ignored one of the most important results of the negotiation and of the title " Unified Thread "—namely, that no party to the agreement establishing the Unified screw thread may modify the standard without consulting the other parties. Mr. Bateman suggested that if the Americans saw any advantage to be gained, they would change their national screw thread standard independently. Without stopping to ask if such a drastic step could in fact be carried out so easily, it surely is worth emphasising that much is gained in that the Unified standard cannot now be changed unilaterally by any one of the three countries.

Mr. Bateman also suggested that the British negotiators were wrong to sacrifice the Whitworth system and to adopt the American system, but he did not say why the Whitworth system is " the finest screw thread system in the world." Thorough tests at the time of the negotiations on the Unified thread established that there was no substantial technical advantage in either the British or the American system. But the very existence of the Unified thread agreement has clearly shown one very positive advantage, in that it has been possible to establish, through the International Organisation for Standardisation, a world-wide standard on the basis of the profile of the Unified screw thread—surely a decision of no mean significance.

Further, I.S.O. is now considering the question of an international pitch-diameter series, and all the circumstances again favour the adoption of the pitch-diameter characteristics of the Unified thread as a world-wide standard, provided that the Continental countries can agree to the use of the converted inch values, which were published in B.S. 1580 in 1948. Such a prospect would certainly have been impossible if the Americans had decided to adopt the Whitworth system instead of vice versa.

Mr. Bateman's last paragraph stands in need of correction. There is no intention whatever to introduce a further Unified standard for pipe threads. What Mr. Bateman probably has in mind is that the British Standard pipe thread has now been confirmed by the International Organisation for Standardisation as the international screw thread for pipes. Here, unfortunately, the Americans will not be in line, and both pipe thread systems will probably persist for a long time.

Finally, Mr. Bateman asks that an official pronouncement should be made as to whether the British Standard Whitworth thread should be abandoned. Obviously this thread is in such wide use here and in the Commonwealth that its early abandonment would be quite impracticable. Nevertheless, it would be only logical to admit that as the adoption of the Unified thread becomes more widespread, the use of the British Standard Whitworth thread will diminish. The rate at which the change-over will take place must depend on the decision of each individual section of industry.

H. A. R. BINNEY,
Director, British Standards Institution.
May 31st.

Central Ordnance Depot, Chilwell

LAST week senior military officers, Government officials and leading industrialists in the engine and automobile field travelled to the Central Ordnance Depot, Chilwell, near Nottingham. The purpose of their visit was to see how the many great administrative and technical problems which scientific development has imposed upon the Royal Army Ordnance Corps and the Corps of Royal Electrical and Mechanical Engineers are being tackled. For the purpose of this occasion demonstrations were of necessity confined to one part of the organisation, that of mechanised transport, which includes armoured fighting vehicles. The party were acquainted with the basic tasks of the organisation during short talks given by the Quarter-Master-General to the Forces, General Sir Ouvry L. Roberts, and his staff. Statistics were given, clearly emphasising the increase both in complexity and quantity of technical equipment used in the Army, and stressing the real need for even more standardisation and the retention of greater simplicity in basic design. There existed a real danger that in embracing all the latest developments in technical development the Army might become cluttered with a multiplicity of increasingly complex and inflexible weapons. Unless these could be efficiently maintained and serviced their functional superiority could prove a handicap rather than an advantage in a campaign. The stage had been reached, it was thought, when the administrative capacity of the Army should be a dominating consideration when functional changes of a weapon or vehicle were being advocated. On this point, General Roberts suggested that more officers should attain sufficient knowledge of the whole field of administration so that the overall superiority of any proposed " frill " could be properly assessed in its full light at the right place and time. It was only possible to demonstrate a few aspects of vehicle maintenance during the visit. This task involved handling 200 makes of motor transport, 250 types of vehicle, and 650 marks or models, the value of these vehicles being £325 million. Last year, 95,000 vehicles were serviced at Chilwell and other depots. The mechanised transport organisation employs over 16,000 personnel, it handles a range of stores exceeding 300,000 different items, and the stocks held amount to 450,000 tons and are valued at £200 million. Mechanical accountancy methods are used and during a tour of the workshops we noticed the extensive use of mechanical handling methods. Another aspect in the repair organisation which was demonstrated was the reclamation of worn components by metal spraying and welding techniques and the use of electrolytic deposition on such parts as splines.

Books Received

Summerson's Platelayers' Guide. Seventh edition. Darlington : T. Summerson and Sons, Ltd., Darlington. Price 12s. 6d.

A Textbook of Metallurgy. By A. R. Bailey. London : Macmillan and Co., Ltd., St. Martin's Street, W.C.2. Price 30s.

Electrical Ignition Equipment. By F. G. Spreadbury. London : Constable and Co., Ltd., 10, Orange Street, W.C.2. Price 25s.

Britain's Railways To-day. Edited by John St. John. London : The Naldrett Press, Ltd., 91–93, Baker Street, W.1. Price 15s.

Locomotives of Many Lands. By P. Allen. London : The Locomotive Publishing Company, Ltd., 88, Horseferry Road, S.W.1. Price 18s.

Industrial Boiler-House Efficiency. By C. F. Wade. London : Crosby Lockwood and Son, Ltd., 26, Old Brompton Road, S.W.7. Price 15s.

Minerals for the Chemical and Allied Industries. By S. J. Johnstone. London : Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 75s.

Comprehensive Guide to Factory Law. By R. McKown. London : Chantry Publications, Ltd., 63, Neal Street, Shaftesbury Avenue, W.C.2. Price 21s.

U.S. Case Study Data on Productivity and Factory Performance : " Fork-Lift Trucks," " 5 Horsepower Induction Motors." Distributed in Great Britain by the Institute of Management, Management House, 8, Hill Street, London, W.1. Price 5s. and 7s. 6d. respectively.

Iron and Steel Institute

No. I

PRESIDENTIAL ADDRESS

THE annual general meeting of the Iron and Steel Institute was held at the Royal Institution in London on Wednesday morning, May 26th, as reported elsewhere in this issue. Following completion of the "business" of that meeting, the incoming President, Mr. R. G. Lyttelton, presented the address, from which we print some excerpts below.

Research

During the last half of the nineteenth century, and particularly in the last quarter, the speed of invention in manufacturing processes received a remarkable impetus as a result of the discovery of the fundamental scientific principles on which industrial processes depend. Most of these had been devised empirically by trial and error.

Science is generally defined as systematised knowledge, but it is broadly true to say that it was not until the present century that organised collaboration was established between science and industry. The scientist and the technologist had few points of contact and little understanding of the potentialities and limitations of each other, which only collaboration between the two could develop and remove. The introduction of scientists to the industrial field, and a scientific appreciation of the technologist, resulted from the development of the application of the scientific method to industrial processes, which has extended to the study of materials, their properties and constitution—and even to their synthesis and manipulation. The scientific method has also been applied to the deployment of plant and personnel, which, together with the study of the problems of administration, have produced a new technology of management. It must be admitted that for many years industry resolutely kept scientists in a separate department from those concerned with production—for consultation only as and when required. As a consequence neither side could understand or appreciate the wide field for co-operation which existed, the exploitation of which has produced a second industrial revolution in the last thirty years. The war of 1914 gave a stimulus to the collaboration of the scientist and the producer, by its demand for the immediate supply of new arms, machinery, materials and devices, irrespective of cost; so that the application of scientific knowledge to industrial production was probably at least ten times faster during the war period than would have been possible without the spur of necessity provided by a struggle for survival.

Thus research has now become recognised as an essential part of the equipment of industry: the steel industry was one of the first to establish research laboratories in the larger works. In 1924 the British Iron and Steel Federation set up a co-operative Research Committee with which the Department of Scientific and Industrial Research and this Institute were associated. This has now developed into the largest co-operative industrial research organisation in Britain, still in collaboration with the D.S.I.R. and the Iron and Steel Institute.

Within the compass of a short address it is only possible to indicate the relation between the development of the production of steel and the advance of material civilisation. Since it is evident that such advance could not have been made in the same time without the discovery and production of steel, it is a logical deduction that this, in the centuries to come, will be called the Steel Age to distinguish it from those which preceded it.

Growth of Population

The increase in population of the United Kingdom from 1740 to the present time could not have been supported without the development of transport and productive machinery, and the application of mechanical power to manufacturing industry and to agriculture, which steel alone made possible. The population of England and Wales in 1066 has been computed at between 1,500,000 and 2,000,000; the iron production was then insignificant—possibly a few hundred tons. It rose to about 50,000 tons in the year 1760 and then increased rapidly (as a result of the application of stone coal to iron smelting, and the Industrial Revolution) to 4,000,000 tons in the year 1860. The first national figures available for steel production in the United Kingdom were 160,000 tons in 1869—iron production in the same year being 5,450,000 tons. Steel production for the present year has been in recent months at the rate of 18,500,000 tons per annum. The rate of growth of population and production of pig iron and steel from 1740 to 1953 is shown in Fig. 1.

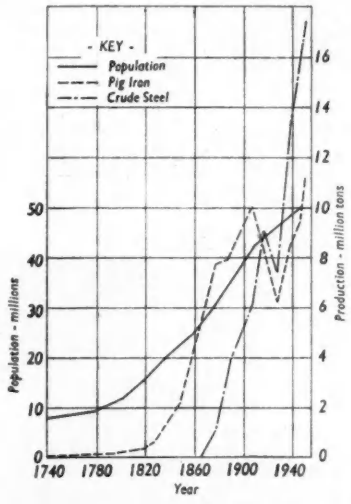


Fig. 1—Growth of population and production of pig iron and crude steel in United Kingdom

It is, of course, correct to say that the increase in population is not directly related to the production of steel, but rather to the advance of human knowledge in all factors concerning our material civilisation, including medicine, health, and hygiene generally. If reduced to its simplest elements, this advance in human knowledge would not have been possible without the increase in productivity and the creation of wealth brought about by the conversion of the natural resources of the earth to the service of man. This in turn has depended upon the application of steel to the creation of prime movers and of power to manufacturing machinery, the latter again based on the production of steel of varying qualities to suit the services required. Thus it is obvious that the rate of consumption of steel per head of population is some measure of the rate of material development of a country. Fig. 2 indicates this for thirteen countries and shows that the consumption of steel per head was greater in Sweden and Canada during 1952 than in the United Kingdom, and that in Australia it is nearly equal.

The Future

What of the future? The Steel Age as we know it is barely 100 years old. Its birth can hardly be dated earlier than Bessemer's invention in 1856, although steel as a separate product was known and made for many centuries before this. It was produced commercially by Huntsman in 1740 by his cementation process. But its cost at that time was of the order of £60 per ton, and it was Bessemer's ambition—which he ultimately achieved after years of experiment—to reduce this to £12 per ton. It may be said that while the previous inventions made a valuable contribution to technological advance in the production of tools and the like, it was not until steel was generally available for structural use and the mechanism of daily life that it exerted the profound influence on the social life and well-being of mankind that is so characteristic of the present century. Table I illustrates the dependence of our industrial economy on steel, thus making it the foundation of our present social and material well-being.

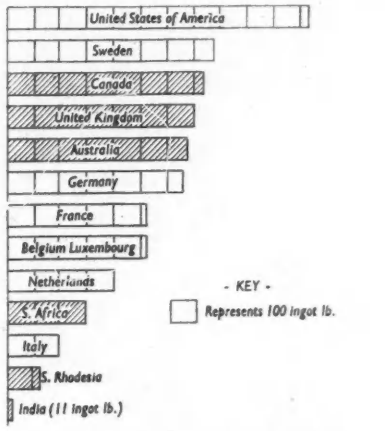


Fig. 2—Apparent consumption of steel per head of population in 1952

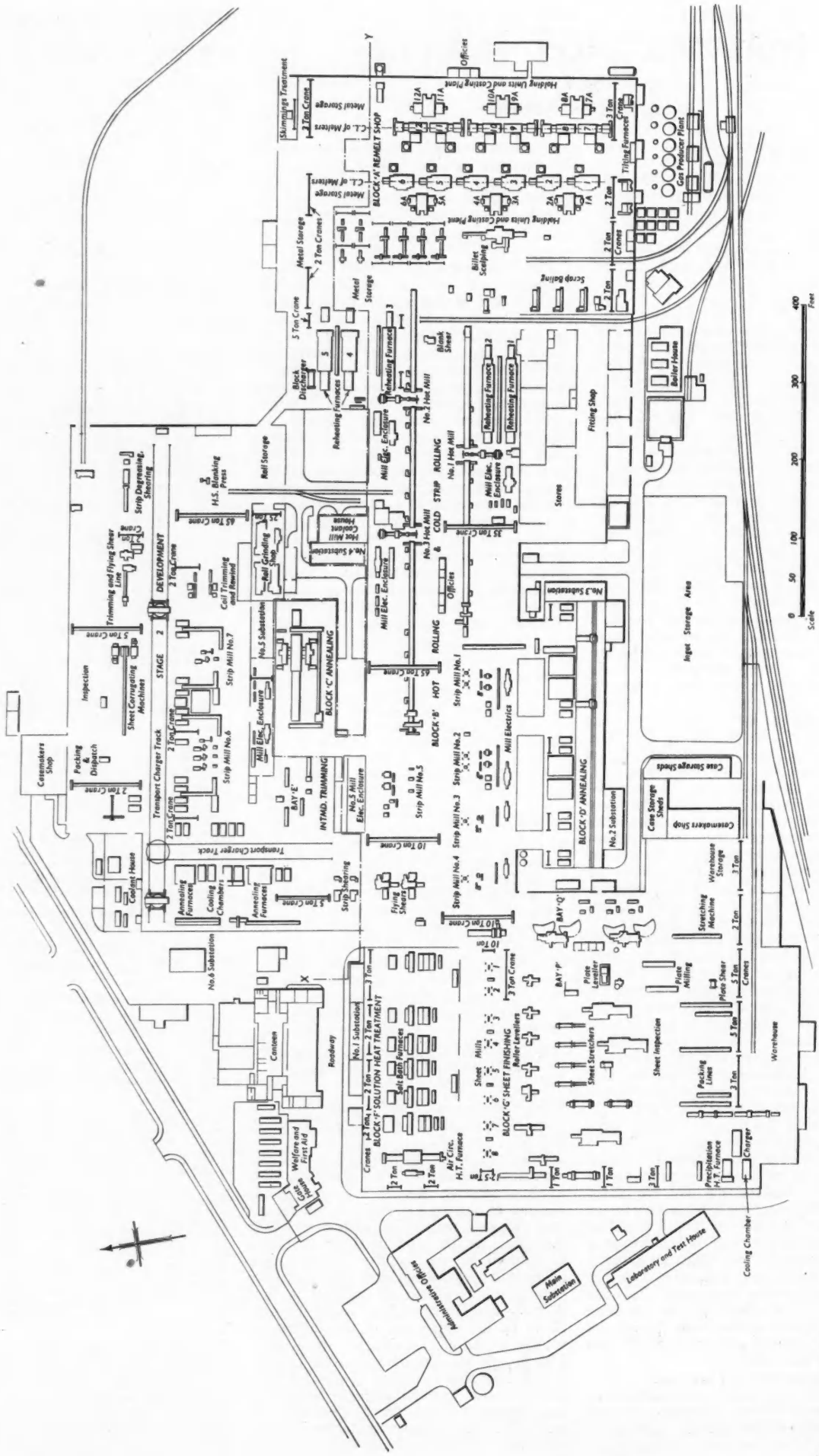
TABLE I—*Deliveries of Finished Steel by Industry in* 1951

Provisional figures including sheet and tinplate

Industry	Thousand tons	Percentage of total
Coal mining	566	5·3
Other mining and quarrying	10	0·1
Iron and steel	371	3·4
Shipbuilding and repair	727	6·7
Marine engineering	127	1·2
Agricultural machinery	166	1·5
Boilers and boiler-house plant	153	1·4
Machine tools	68	0·6
Stationary engines	29	0·3
Textile machinery and apparatus	65	0·6
Constructional engineering	902	8·4
Other non-electrical engineering	948	8·8
Electrical machinery and apparatus	437	4·1
Motors, cycles, aircraft	1,089	10·1
Rolling stock—Railway Executive	198	1·8
Rolling stock—other makers	327	3·0
Bolts, nuts, screws, &c.	439	4·1
Drop forgings, laminated springs, &c.	434	4·0
Wire manufactures	290	2·7
Hollow-ware	627	5·8
Metal furniture, windows, &c.	484	4·5
Tools, implements, &c.	108	1·0
Building and contracting	407	3·8
Gas, electricity, water	94	0·9
Railways (excluding rolling stock)	291	2·7
Other U.K. consumers	338	3·1
Stockholding merchants	1,094	10·1
Totals	10,789	100·0

(To be continued)

ALUMINIUM MILL AT FALKIRK



Plan of the Falkirk mill showing the layout of the machinery in Stage 1 and Stage 2 development

Aluminium Mill at Falkirk

No. I

The light alloy rolling mills which were constructed at Falkirk to produce material for military purposes were acquired by the British Aluminium Company, Ltd., after the war and since then have been modified and adapted to meet the post-war market requirements. The work of conversion has gone forward in two stages, first the adaptation of existing plant and, secondly, the construction of new buildings to house additional processing plant to increase the capacity of the mill.

SINCE the war the light alloy rolling mill of the British Aluminium Company, Ltd., at Falkirk, has been expanded, modified and adapted from war-time production to meet the demands of the home and overseas markets. This work has gone forward in two stages, Stage I was initiated in 1947, while Stage II was begun in 1950 and recently we were able to visit the works to inspect the mill as developed at present. Broadly, the bulk production potential of the original mill has been expanded and provision made in planning the extensions and installing new equipment to ensure flexibility of production so that manufacturing capacity would be adequate to meet the diversity of post-war market requirements.

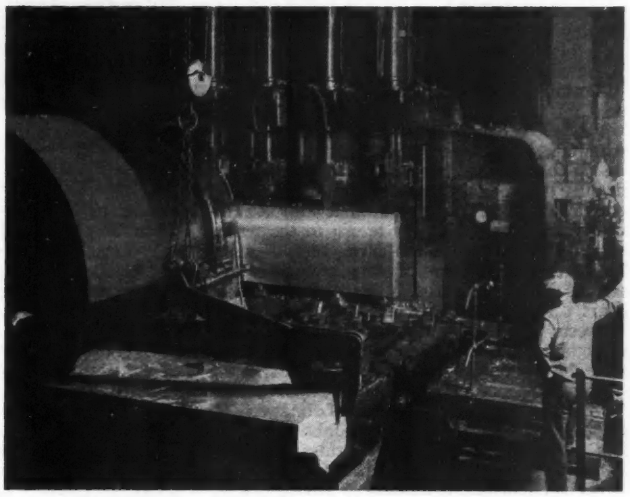
The mill products range from plate in thicknesses up to 4in or more to sheet and coiled strip down to 0·008in thick. Plate material can be rolled up to a maximum of 30ft by 6ft and 1800 lb weight, the corresponding size for sheet being 21ft by 6ft, while the size limits for coiled strip are 54in wide by 0·128in thick and a coil weight of 2000 lb. Corrugated sheet in a variety of sections is produced and also material with an embossed finish, the latter being available in light and heavy stucco.

The nucleus of the present works was planned in 1942 to produce material for military purposes, mainly strip and sheet up to 72in finished width, and the plant was opened officially in June, 1944. At the conclusion of the war the plant, consisting of some 14·5 acres of buildings on a site of about 49 acres, was acquired from the Ministry of Supply by the British Aluminium Company, Ltd., and plans prepared for reconstruction to satisfy commercial production requirements. To-day the factory has 21 acres of buildings standing on a site of 55·5 acres after the completion of Stage I and Stage II development plans. The site selected, which is well served by road and rail, called for a certain amount of levelling, but the bearing qualities of the ground permitted a loading of 3 tons per square foot to be adopted.

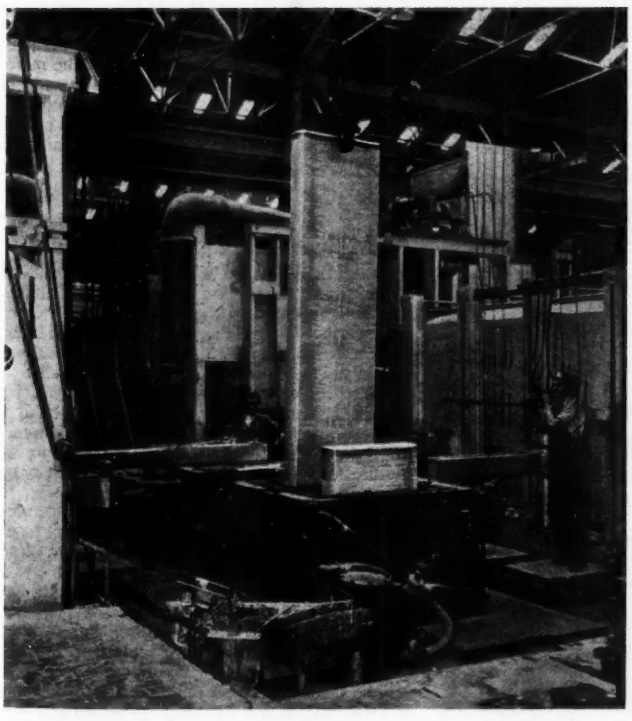
Stage I Development

Stage I development represents the parent factory as initially laid out, with the rearrangement and adaptation of the existing plant, and the incorporation of new equipment in the production lines, and is shown in the line drawing which we reproduce herewith. The line *X*, *Y* marks the approximate boundary between the two stages of development, Stage I being to the south of the line. The main buildings are steel-framed structures enclosed with unlined sheeting, while an 8ft high 9in brick wall bounds all production blocks, and our illustrations show certain items of the production equipment.

Operations commence in the remelt shop, Block "A," which measures 470ft by 300ft, including a 120ft extension added during Stage II development. Here the incoming ingot is received, stored and converted into cast rolling blocks. The shop consists of two furnace bays 80ft and 60ft wide, respectively, served by 2-ton and 3-ton cranes and another two bays which house the metal stores, block preparation equipment and scrap baling plant. Side wall louvre ventilators provide for the natural extraction of fumes, assisted by the jack roof construction and augmented by forced extraction at the north end.



Rolling blocks held by hydraulic clamps in a scalping machine. The power-operated block manipulators are shown



Semi-continuous casting machine in remelt shop with a cast rolling block extracted. A holding furnace can be seen to the right with a melting furnace in the background

Twelve fixed-hearth Priest furnaces disposed in two lines, back to back, are the main melting units and operate over a temperature range of 700/770 deg. Cent. Six furnaces have a bath area of 14ft 6in by 7ft 3in and a capacity of 10 tons, and the remaining six have a slightly larger size of bath and a capacity of 13·5 tons. All the furnaces are oil-fired, each having three Laidlaw Drew medium pressure burners operating on an atomising air pressure of about 30 lb per square inch. Exhaust gases from each melting chamber preheat the charge metal in a hearth and then pass through a recuperator to heat the secondary air. An electrically operated screw-driven pusher delivers the charge metal to the preheating hearth while fork-lift trucks deliver the charge to the loading point. In association with each melting furnace is a holding furnace, in which the metal is degassed, six are of 5 tons capacity and six of 7 tons capacity and all are fired by scrubbed producer gas. Launders connect the holding furnace to the tapping tuyeres of the melting unit. For the production of alloy hardener there are three 2-ton capacity axis tilting barrel pattern furnaces installed.

A close check is maintained upon the composition of the alloy and samples are taken at intervals and prepared for spectrographic analysis by a "Quantometer," supplied by Applied Research Laboratories, Glendale, California, which is able to give the chemical composition in about five minutes.

The rolling blocks, measuring up to 10in thick, 48in wide, or 11ft in length and weighing up to 2 tons, are produced in semi-continuous, hydraulically operated, casting units, supplied by Glenfield and Kennedy, Ltd., which are capable of lowering and raising a maximum load of 3·5 tons at controlled speeds. Cooling water for the casting mould is drawn from the canal water ring main. For preparing the blocks for rolling there are several Noble and Lund table saws for end cropping and Holroyd milling machines, having cutter heads of 38in to 50in diameter, for scalping the major faces. In addition to the foregoing there is an Ingersoll horizontal plano-miller, fitted with an automatic block manipulator and hydraulic clamping gear, which can deal with blocks up to 16in thick, 63in wide and 120in long and will take a single cut of $\frac{3}{8}$in depth. The feed speed ranges from $2\frac{1}{2}$in to 108in per minute and the machine is powered by a cutter head drive of 220 h.p.

Scrap in the form of sheet is sheared or cut into convenient sizes in an automatic machine and charged through the furnace side doors, but for dealing with smaller scrap there are three 180-ton and one 130-ton baling presses, which provide scrap bales measuring 18in by 27in by 8in and 18in by 30in by 6/11in respectively. For handling purposes the shop overhead cranes are assisted by Coventry Climax diesel-powered fork-lift trucks of 6000 lb capacity and by Greenwood and Batley platform lifting battery trucks of 5 tons capacity.

Block "B" forms the main rolling mill and consists of two 100ft spans by 825ft in length, the north bay being served by one 65-ton and one 10-ton crane and the south bay by a 35-ton crane and a 10-ton crane built of aluminium alloy. The mill plant is disposed in two independent lines running from east to west, beginning with the hot breaking down mills, and associated block reheating plant, and terminating in cold finishing mills on the south side and strip flattening and flying shear lines on the north. Ventilation is by adjustable side wall

louvres and 60in Robertson ventilators.

For the south bay hot line the blocks are prepared in two producer gas-fired pusher pattern Priest reheating furnaces sited parallel with the mill runout. Each furnace, which is 76ft in length, can take blocks up to 48in wide and 5ft long, mounted on edge in groups of two or three on steel skips which are moved through the furnace by a hydraulic pusher having a 75 tons thrust. Two hot gas fans in each furnace ensure the recirculation of the combustion products and efficient heat transfer throughout the blocks and the electro-hydraulically operated furnace doors are interlocked with the hydraulic pusher. The dischargers transfer the blocks to a roller track leading to the mill table and also extract the skips which are returned by conveyor to the charging end. The hot block is deposited on the 70ft long live roller feed table leading to No. 1 hot mill, which is a 34in by 72in two-high reversing mill supplied by the Brightside Foundry and Engineering Company, Ltd., and powered by B.T.H. motors. Besides the main ingoing table there is a 40ft long idle roller table, and this arrangement is duplicated on the outgoing side, but with an additional 70ft of live roller table, which terminates in a Head Wrightson hot trimming and coiling line. This line, which is capable of handling strong alloy material 4ft 6in wide by ⅜in thick, incorporates an up-cut shear and there is a scrap cutter for dealing with hot edge trimmings, which is equipped with a conveyor and elevator for discharge into scrap bins for return to the remelt shop. The driven tables have 14in diameter hollow cambered rollers, 5ft long, pitched at 15in centres and driven through line shafts and bevel gears. There is a 10 per cent speed differential between the ingoing and outgoing drives for draught compensation and at the end of the run-out table there is an 8ft guillotine blank shear.

The mill rolls are of solid forged alloy steel having a barrel surface hardness of about 65 deg. Shore " C " and are mounted in fabric bearings. Both the roll barrels and bearings receive a common supply of soluble oil lubricant coolant, which is circulated by a pump of 350 gallons per minute capacity and can be preheated by high-pressure hot water coils. Blocks up to 10in thick are accepted by the mill and there are sets of electrically powered, independently operated pusher pattern manipulators on both ingoing and outgoing sides. The mill drive has a rating of 0/2000/2000 h.p. r.m.s. at 0/40/51 r.p.m., and the equipment consists of a 2000 h.p. slipring induction motor operating at 6·6kV, while two d.c., 850kW, 440V machines make up the generating unit and there is a 13-ton flywheel having a stored energy of 90,000 h.p. seconds at 1000 r.p.m. Forced draught ventilation is used for the mill motor, the air passing through a Visco filter at 20,000 cubic feet per minute.

Fig. 5—No. 3, 23in and 52in by 96in four-high hot mill showing the ingoing table and part of the 3000 h.p. mill motor and drive

To serve No. 2 hot mill and the line in the north bay of Block " B " there is a Priest reheating furnace similar to the units serving No. 1 mill, but capable of taking blocks 8ft long. In addition there are two more furnaces which form part of Stage II development, and are producer gas fired units, supplied by Gibbons Furnaces, Ltd. Each have a hearth length of 51ft, are fitted with a 90 h.p. electrically operated screw pusher of 100 tons capacity, and are capable of taking blocks 10ft in length. A Wellman Smith Owen overhead discharger of 10,000 lb capacity serves all three furnaces, assisted by a 5-ton Wellman block handling crane, and deposits the block on a powered track serving the mill table. The mill, which is a 35in by 96in two-high reversing unit, furnishes 6ft wide finished material, but has a drive identical with that of No. 1 mill On each side of the mill there are 40ft long live roller tables with rollers of 7ft face width, terminating on the ingoing side in a 50ft long idle roller table and on the outgoing side forming part of the 150ft long ingoing table for No. 3 mill.

This mill, built by Davy and United Engineering Company, Ltd., operates in tandem with No. 2 mill and is a 23in and 52in by 96in, four-high reversing unit, having solid forged steel work rolls and cast steel back-up rolls and capable of taking 8in thick blocks. For roll changing there is a motorised sledge, to extract the complete roll and chock assembly, operating in conjunction with hydraulic jacks built into the mill housings. There is a run-out table some 220ft in length which terminates in a Head Wrightson 80in wide hot trimming and coiling line incorporating an up-cut shear capable of cropping 80in wide by 1in thick hot strong alloy plate. The main and auxiliary drives were supplied by the British Thomson-Houston Company, Ltd., and the main motor of 0/3000/3000 h.p. r.m.s. at 0/40/64 r.p.m. has a short time overload capacity of 100 per cent and a maximum cut-out torque some 20 per cent higher. Forced ventilation is provided at the rate of 25,000 cubic feet per minute of filtered air. Direct current at 440V is supplied to the motor by a motor generator set driven by a salient pole, a.c., synchronous motor of 3700 h.p. at 1000 r.p.m., 6·6kV, the excitation of which is under Amplidyne control, which permits the power factor to be maintained at about unity up to twice full load. The motor has a maximum synchronous pull-out torque of not less than two and one-half times full load and starting is by pony motor, while there are three 850kW d.c. generators capable of frequent peaks of twice full-load current.

(To be continued)

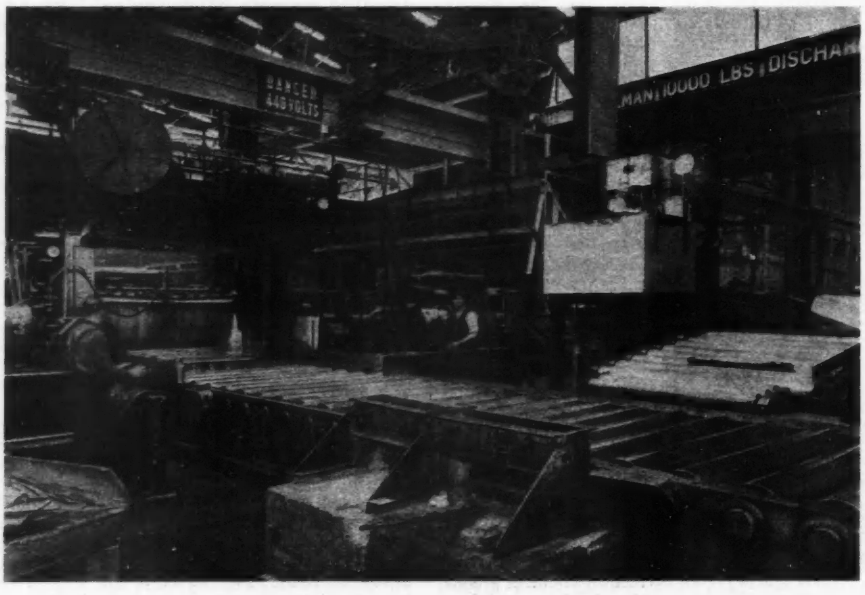


Fig. 4—No. 2, 3in by 96in two-high hot mill showing the block discharger and roller track delivering to the ingoing mill table

Mobile Forging Manipulators

PARTICULARS have been received of a 5-ton capacity mobile forging manipulator, designed and built recently by the Wellman Smith Owen Engineering Corporation, Ltd., Parnell House, Wilton Road, London, S.W.1. This machine, which weighs some 24 tons when unladen, is intended for charging and discharging reheating furnaces and subsequently handling and manipulating the ingots or billets under a forging hammer or press. It is driven by a constant-speed electric motor, but is equally well suited for the use of an oil engine as a prime mover.

The general design of the machine can be seen in the drawing and photograph on the next page.

Hydraulic power for actuating all the motions of the machine is supplied by a pump unit with automatic delivery adjustment, giving stepless speed control. The six motions for gripping, parallel hoisting, rocking hoisting, bar turning, travelling and steering are obtained through suitable control valves. The operating controls for the machine are on one side at the rear in a position from which the operator has a clear view of his surroundings when travelling and of the workpiece during forging operations or when reaching into a furnace to take up or put

down ingots or billets. All the motions, except steering and travelling, are controlled by lever-operated valves conveniently arranged in front of the operator's position. Steering is controlled by means of a steering wheel and the travel speed by a pedal, the forward or reverse direction being selected by a lever-operated valve at the side of the operator. A pedal is also provided for operating the hydraulic wheel brakes.

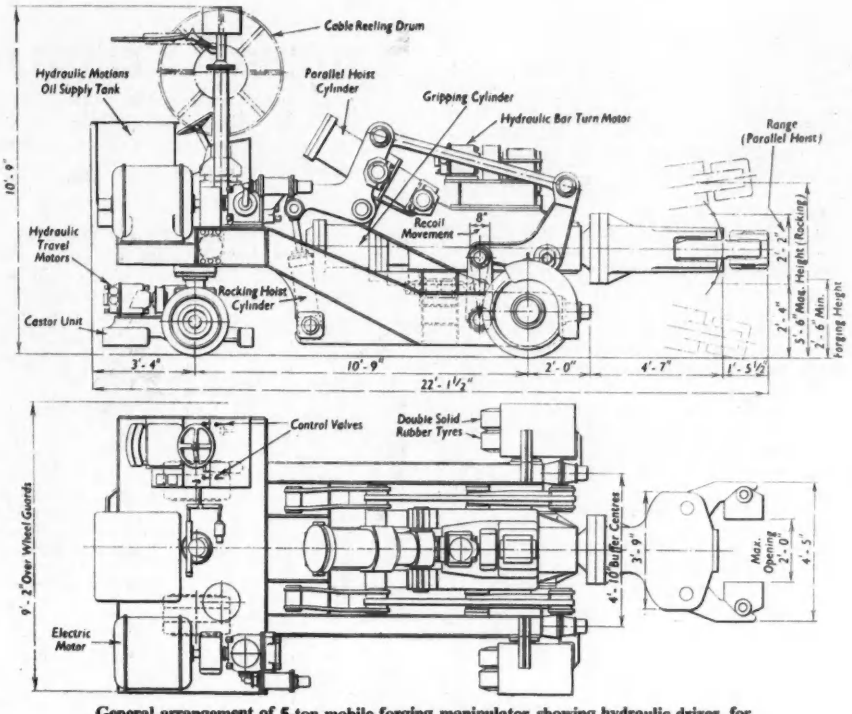
The speeds of the various motions for the forging manipulator are as follows :—Travelling, 250ft per minute ; parallel hoisting, 16ft per minute ; rocking hoisting, 26ft per minute ; bar turning, 10 r.p.m.; and gripping, 8½ seconds full range. The manipulator has a rated capacity of 5 tons with an 8ft long billet of uniform section gripped across the corners, but when longer billets are to be forged the weight for gripping and overturning is proportionately decreased.

The grip head fitted on the machine is made as small as possible to enable the maximum number of ingots or billets to be placed into the furnace and also to provide the operator with a good view of the grips when forging. These grips are operated by levers engaging in a crosshead in the grip head and actuated by a pull rod connected to a double-acting hydraulic cylinder mounted at the rear of the spindle frame. To permit rotation of the grips while taking the thrust of the grip motion spherical roller bearings are fitted in the piston. The hold of the grip is maintained against the effects of possible oil leakage by the use of a piston/spring hydraulic accumulator. The grip levers and jaws are easily removable for replacement by tong grips fitted with pointed spuds used for forging discs or blocks.

The grip head is rotated by a hydraulic motor, capable of running continuously in either direction, and of turning the spindle and grip head through totally enclosed gearing. Any shock transmitted in a rotary manner during forging, particularly with hammers, is absorbed by a resilient gear wheel fitted on the main spindle, but if this shock becomes excessive it is taken by unloading valves associated with the hydraulic motor. The main spindle is mounted on substantial plain bearings and the thrust of the gripping operation is taken through a spherical roller thrust bearing.

Two hoist motions are provided, one enabling the grip head to be lowered to the floor level or raised above the working position and the other enabling the head to be raised or lowered in a parallel manner when forging.

The parallel hoisting motion is operated by means of lever mechanism formed by bellcranks pivoted on the spindle frame, and the vertical members of the bellcranks are connected by tie rods. The horizontal bellcrank members attached to the chassis at the rear are connected to the rocking hoist cylinders and those at the front by support links which are members of a horizontal floating mechanism. Set between the rear bellcranks is a trunnion-mounted hoisting cylinder, the piston of which is pivoted to the spindle frame. The hoist piston has fitted in it a hydraulic recuperator of special design, which provides vertical float to the spindle frame and grips to take up deflection of the workpiece during forging. If this deflection or resultant shock becomes excessive the cylinder is unloaded by a hydraulic relief valve. While the parallel hoist motion mechanism is able to recoil from the forging blow, it does so without oscillation, thus providing resilience with a steady action. This provision is important when the work involves forging to a close finish.



General arrangement of 5-ton mobile forging manipulator showing hydraulic drives for the various motions

In addition to the vertical resilience provided by the parallel hoist mechanism, horizontal float is also provided by the front support links, which are pivoted to the chassis and connected to recoil springs. Free horizontal floating is provided so that very rapid longitudinal movements resulting from elongation of a billet when forging with a hammer can be readily absorbed. Preloading is provided, however, to prevent unnecessary floating when placing a billet on the anvil. The amount of permitted recoil for the present machine is 4in in the forward or reverse directions.

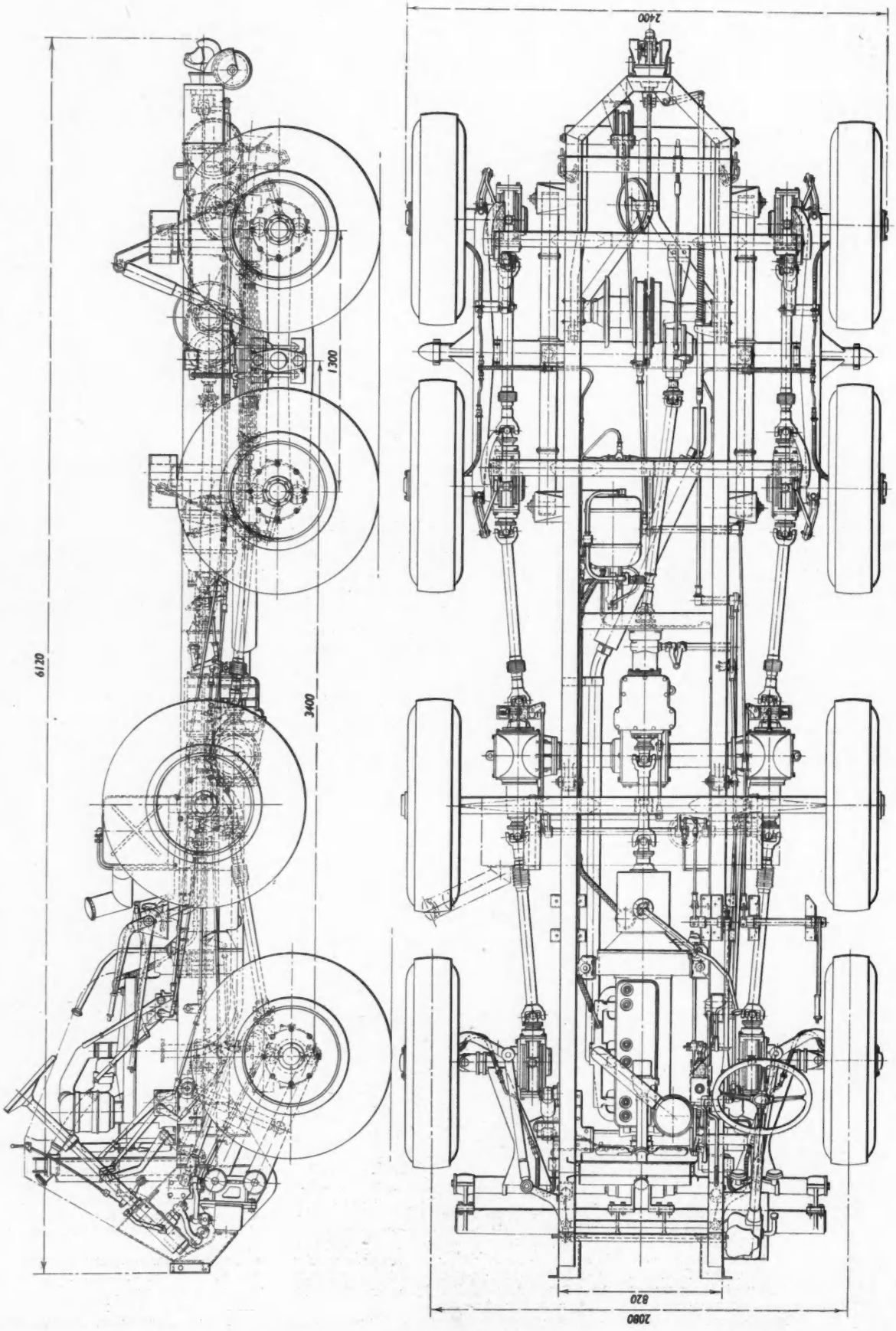
The rocking hoist motion provided enables the grips to be lowered to the floor or raised above the highest parallel position and is effected by two double-acting hydraulic cylinders, which raise or lower the rear bellcranks, thereby rocking the spindle frame about the pivoted connection of the front bellcranks to vertical links of the recoil mechanism. If the machine is overloaded for this motion oil is released from the cylinders by a hydraulic relief valve to prevent lifting beyond the designed capacity.

The manipulator is mounted on solid rubber-tyred wheels fitted to the axles on taper roller bearings and the front wheels are provided with hydraulically operated brake drums. Twin hydraulic motors, which drive the rear wheels through totally enclosed worm gearing, are piped in parallel, but as each motor drives a single wheel a simple differential action is obtained without need for complicated gearing. The castor unit is pivotally mounted on a steering centre post to give compensation for an uneven floor. This centre post is mounted on the chassis through taper roller bearings and can be rotated to give up to 180 deg. movement of the castor unit through a double-acting hydraulic cylinder which operates a toothed ram engaging with a pinion mounted on the centre post. The hydraulic steering is sufficiently powerful to enable the castor to be turned when the machine is stationary. The 90 deg. angular movement provided in each direction enables the manipulator to turn completely about its front axle, thus giving great manœuvrability for travelling in restricted areas. Steering is effected by a wheel which operates the control valve through a differential link also connected to a follow-up rack and pinion gear.

This 5-ton manipulator is one of a range of similar machines made in capacities of ¼, 1, 1½, 2, and 3 tons, and we are informed that the construction of larger machines is contemplated by the makers.

5-ton capacity mobile forging manipulator with hydraulically operated motions

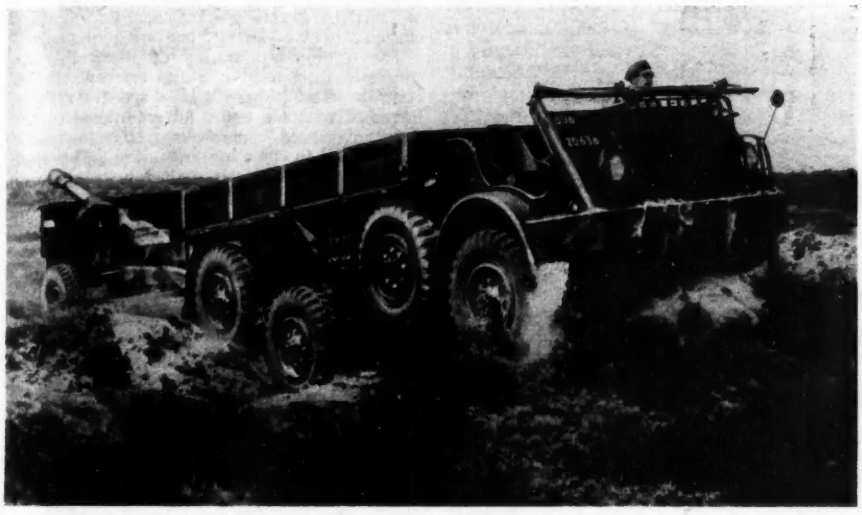
CHASSIS OF SIX-WHEEL DRIVE ARTILLERY TRACTOR



Six-Wheel Drive Artillery Tractor

The 3-ton military truck made by Van Doorne's Automobielfabriek N.V., which we describe in its arrangement as an artillery tractor, has a six-wheel drive, independent suspension and torsion bar springing. Its 131 b.h.p. engine drives all wheels through a five-speed gearbox and two-speed transfer box, which incorporates the differential.

MILITARY vehicles and trailers for a variety of applications have been developed in recent years by Van Doorne's Automobielfabriek N.V., of Eindhoven, Holland, and we recently had an opportunity to inspect one of the firm's latest 3-ton artillery tractor vehicles which is of interesting design. This vehicle has been built to comply with rigorous military requirements and, as can be seen from the illustrations we reproduce, is capable of cross-country hauling under arduous conditions. It has a six-wheel drive and ten gear ratios are provided through a five-speed gearbox and a two-speed transfer box. A maximum road speed of 51 m.p.h. can be attained when the vehicle is loaded with 3 tons of equipment and hauls a 2-ton load, or is loaded with 2 tons of equipment and hauls a load of 3 tons. Its maximum continuous speed is 45 m.p.h., whilst its average cruising range at 38 m.p.h. without a trailed load is 310 miles.



Six-wheel drive artillery tractor hauling gun over rough country. The tractor has independent suspension and torsion bar springing and its 131 b.h.p. engine drives through a five-speed gearbox and two-speed transfer box

The general arrangement of the vehicle chassis can be seen in the drawing on the page opposite. It has a welded steel frame built of box members forming a rigid structure capable of withstanding the heavy loads imposed in cross-country operation. An extension at the front of the frame supports a heavy projecting cross beam member, which serves to protect the steering and other gear, and a supplementary frame assembly beneath the rear of the chassis carries a powerful winch unit.

The six-cylinder "Hercules" petrol engine fitted develops 131 b.h.p. at 3200 r.p.m. Power is transmitted through a 14in diameter heavy-duty, single dry plate clutch to the main five-speed constant-mesh gearbox coupled by a short propeller shaft to a two-speed transfer unit in the centre of the chassis frame. This transfer unit incorporates the differential, which is coupled by short cross shafts to bevel gearboxes mounted outside the main longitudinal members on each side of the chassis frame. From these bevel boxes the drive is transmitted by propeller shafts to each wheel. These propeller shafts have a universal joint at each end and a telescopic splined sliding section which compensates for wheel displacement on rough terrain. It will be noted that the bevel boxes of the drive are protected from possible damage by the method of suspending the spare wheels on a projecting cross axle.

Each wheel is mounted on a very short stub axle driven through a compact worm gear unit. The rear wheels are mounted in tandem on two longitudinal beams which are carried by a heavy cross axle supported from the main frame by large laminated springs. The front wheel drive can be disengaged through dog clutches in the bevel boxes for normal running, and each of the wheels is mounted on a double universal joint which is not affected by the suspension. With this arrangement the maximum turning angle is obtainable for steering, and although it has a wheel base of just over 13ft the vehicle has a turning circle of only 52ft. In the independent front wheel suspension provided each wheel is supported by two trailing arms and sprung by two cross-mounted torsion bars. The wheels are steered through a cam and lever gear system and a divided track rod. The steering linkage is not affected by vertical movements of the wheels. Double-acting telescopic shock absorbers are fitted to each of the six wheels of the vehicle.

An air-assisted hydraulic braking system serves each wheel and is supplemented by a hand-operated transmission brake which acts on drums fitted behind the bevel boxes on each side of the chassis. The spare wheels are free to rotate on their fixed axle, and in rough bogging country they serve as supplementary supporting wheels.

A winch mounted at the rear of the frame is driven by a power take-off from the rear of the transfer gearcase and an automatic pintle hook is attached to the end of its 165ft long cable. This winch is controlled from the driver's seat and is protected by a torque limiting device. The coupling of the gun is effected by one man. After the pintle hook has been disengaged by the driver in the cabin by operation of a lever the hook can be attached to the gun. The winch is then engaged and as the cable is winched in, the tail of the gun is lifted. The conical front end of the hook is guided by a roller to its seating. When the hook comes into its final position a pin is pushed in and the hook is automatically locked. At the same time the winch is automatically disengaged.

If the tractor with the gun in tow has to cross terrain which might be too difficult to be passed by both at the same time, the gun can be disengaged by the driver from his seat. The gun remains in its position, but it is still attached to the tractor by the cable. The tractor alone can move on until a favourable position has been reached, and from this position the gun can be hauled in as described without the driver having to leave his seat. The gun can also be towed by means of the cable by applying the winch brake and, if necessary, it is even possible to winch the gun in while driving.

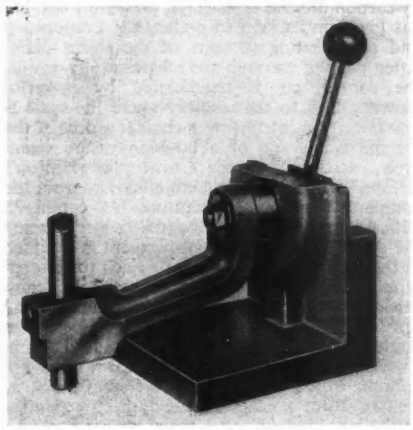
In addition to its uses as an artillery tractor and general-purpose military truck, this vehicle has also been adapted for service as an aerodrome crash and fire-fighting tender. The tender has a water tank of 780 gallons capacity and a 75-gallon foam liquid tank. A rotary pump used for making the foam is driven at 1400 r.p.m. from the power take-off of the main engine and has a capacity of about 3600 gallons per minute. In the pump, air, water and foam liquid are beaten together by the rotor and delivered in the form of a fine foam to two 4in delivery hoses, 960ft long. Under normal conditions a foam jet up to 140ft long can be delivered by the tender.

Two four-wheeled trucks also made by the firm are designed and built on generally similar lines with all-wheel drive, independent wheel suspension, torsion bar springing, &c. One of these vehicles is a ¼-ton general-purpose truck or personnel carrier, and the other can be arranged as a 1-ton weapon carrier, staff car or ambulance.

Radius Dressing Fixture

A NEW radius fixture made by Engineering Diamonds, Ltd., of 26, Warwick Row, Coventry, is illustrated below. In this fixture provision is made for limitation of arc by means of adjustable stops in the base, and to facilitate selection of any particular arc an integral protractor calibrated in degrees is provided.

The fixture can be used horizontally, as illustrated, or vertically, and the square ground faces of the base are arranged for either magnetic chuck or clamp mounting. To utilise the graduated feed on the machine it is recommended that the horizontal position be used on surface grinding machines and the vertical position on tool and cutter grinders. The handle can be fitted to suit either of the two stations according to the position of the fixture. The diamond carrying member has a ground datum face exactly 1in from the pivot centre line, so that any desired radius can be set by slip gauge or similar measurement to the diamond point.

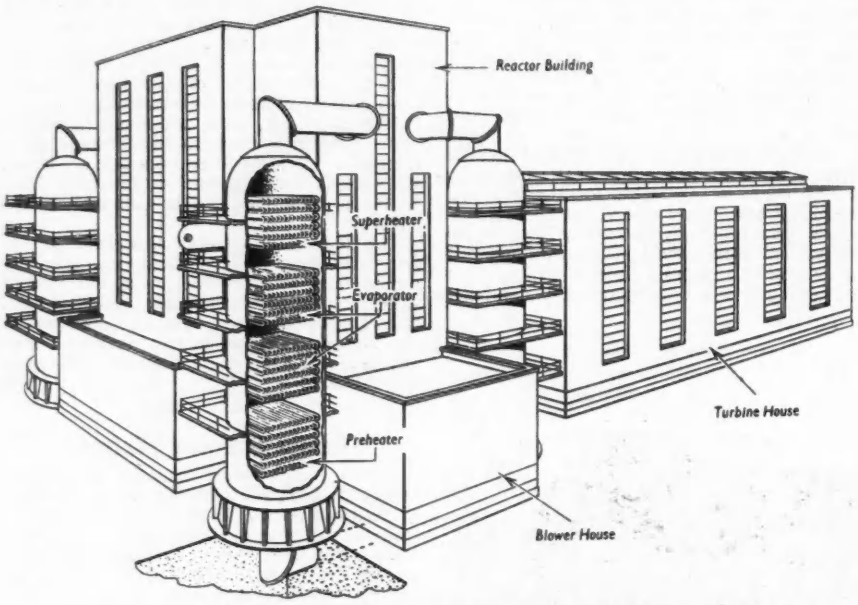


Radius dressing fixture, suitable for vertical or horizontal mounting and for forming convex or concave radii up to ¾in on grinding wheels up to 10in diameter

The fixture has a capacity of up to ¾in radius both concave and convex, and can be used on grinding wheels up to 10in diameter. In the horizontal position the height to the pivot centre is 3½in, and in the vertical position the height to the diamond is 6in. Three of the makers' standard diamond tools are recommended for use with the fixture.

Steam Generation at the Calder Hall Atomic Power Station

WE have received brief particulars of the steam-raising plant which is to be supplied by Babcock and Wilcox, Ltd., for Britain's first atomic power station—at Calder Hall, in Cumberland. The power station will consist, essentially, of a central turbine house with a nuclear reactor at each end, the heat from each reactor being used to generate steam in four steam raising towers. These vertical towers are 80ft high and in appearance they are suggestive of oil refinery practice rather than conventional boiler plant.



Drawing showing principles of steam raising tower at Calder Hall. Each 80ft tower contains h.p. and l.p. sections, comprising preheater, evaporator, and superheater

Heat generated in the graphite-moderated uranium reactors is conveyed to the steam plant by carbon dioxide under high pressure ; the hot gas gives up its heat to preheating, evaporating and superheating sections of the steam plant. After passing through the steam-raising towers the cooled gas is recirculated by powerful blowers back to the reactor, where the cycle is repeated. An interesting technical aspect of the scheme is the use of a double-pressure steam cycle, described in Sir Christopher Hinton's lecture,* to obtain maximum efficiency from the comparatively low temperature (as compared with a conventional furnace) of the gas entering the steam towers. The arrangement is outlined in the accompanying diagram. Each tower contains, in effect, two separate sets of steam-raising equipment, there being separate h.p. and l.p. economiser, evaporator and superheater sections, each with its own drum and feed pump. The turbine plant will be designed with a l.p. section, which will receive live steam direct, as well as steam which has already been expanded in the h.p. blading.

To obtain the maximum heat transfer in the towers all heating surfaces are of stud-tube construction to give extended surface. The studs are flash-welded and have smooth surfaces and a profile giving good aerodynamic properties. An important requirement of the internal heating surfaces is that there should be no leakage of steam or water into the coolant gas, otherwise contamination of the internals of the reactor—the fuel elements and graphite—would result. Accordingly there will be no joints inside the pressure shells except those which, once completed in the shops and exhaustively tested, will not be required to be broken throughout the anticipated life of the plant. In addition, because of the high pressure of the coolant gas (in the interests of economy in blower power) the whole system must be built to withstand this pressure without any possibility of leakage.

Another point of interest is that there are no products of combustion in the generally accepted sense, and there is no need, therefore, for the orthodox chimneys. Two comparatively small vent pipes are provided on each reactor house for extracting any heat loss from the reactor which is not transferred to the steam towers. Filter plant is provided to ensure that no atmospheric dust particles that might find their way into the reactor space are not discharged in a radioactive condition. Wherever possible, the approach to the design and construction of the steam plant has been orthodox.

The complete steam towers and their associated feed pumps, &c., are being supplied by Babcock and Wilcox, Ltd. The reactors are being built by the Department of Atomic Energy, the pressure vessel, or outer shell for the reactor, being made by Whessoe, Ltd. The circulating gas blowers and pipework and turbo-alternator plant are being supplied by C. and A. Parsons and Co., Ltd. The main contractor for the station building is Taylor Woodrow, Ltd.

* "Nuclear Reactors and Power Production," James Clayton Lecture, Institution of Mechanical Engineers, February 26, 1954. See also THE ENGINEER, March 5, 1954.

Methane Burning Gas Turbine

THE gas turbine adapted for methane fuel by Ruston and Hornsby, Ltd., for the Kuwait Oil Company, Ltd., having passed its acceptance trials, was demonstrated recently at the company's Lincoln works. It is otherwise similar to the standard "TA" gas turbine which the company is batch producing, a total of twenty-four units having been ordered. Other of these machines have also been successfully developed to burn diesel oil, coal tar fuel and peat. The machine has a continuous maximum rating of 1260 b.h.p.

This particular turbine will drive a nine stage crude oil pump and is for use in the oilfields for main line pumping duties.

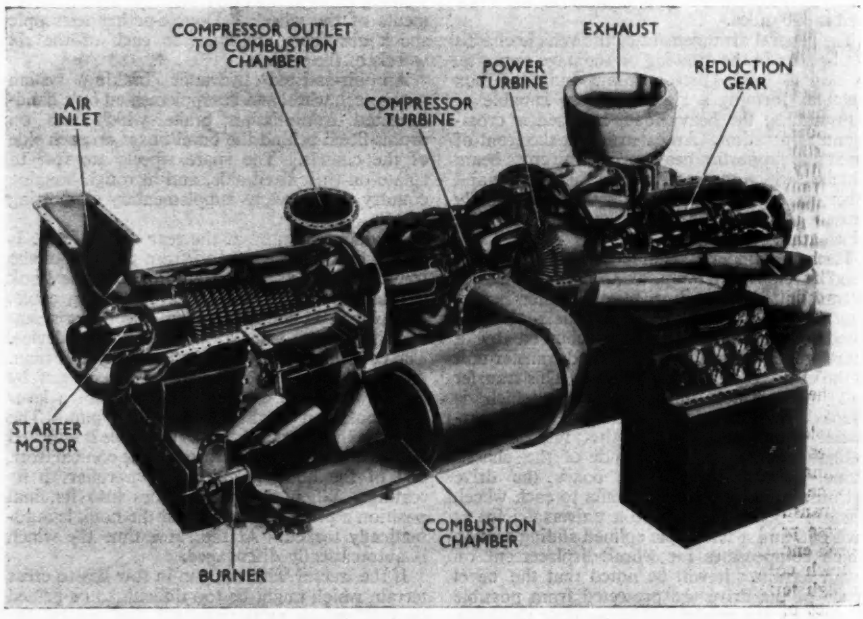
The purpose of the demonstration was to show that natural gas, which is available in almost unlimited quantities on many oilfields, can be burnt with the same degree of efficiency and control as liquid fuels.

The fuel used was washed sludge gas, approximately 90 per cent pure methane. This gas was obtained from the West Middlesex Sewage Works and transported to Lincoln in a multi-bottled trailer. Bottled at a pressure of 2000 lb per square inch, it was passed through a reducing valve to reproduce site conditions of 140 lb per square inch pressure. Infra-red carbon monoxide and methane meters have indicated a combustion efficiency in excess of 99·5 per cent at all loads.

The turbine was started up illustrating the simple starting technique and extreme ease of control. The power turbine speed was then increased to come under governor control and the "overspeed" emergency shut-down trip was allowed to come into operation. This shut-down device operates by reducing the servo oil pressure, causing the fuel to be shut off and brings into operation the klaxons and auxiliary lubricating oil pump.

The unit was then started and run up to the governed speed. The pump speed was then increased to 1500 r.p.m. and the load built up to 1000 b.h.p. to demonstrate the governor droop characteristics and speed resetting at high load.

High gas temperature warning was then demonstrated which, when the lubricating oil temperature or maximum gas temperature rise above a set value, a klaxon sounds. Further slight rise in temperature causes the machine to be shut down automatically. Afterwards the load was reduced to 400 b.h.p. approximately at 1465 pump r.p.m. demonstrating governor droop and speed resetting. Finally, the load and pump speed was reduced until low lubricating oil pressure trip shut down the plant. This action also reduces the servo oil pressure and brings into operation the klaxons and auxiliary lubricating oil pump.



Ruston gas turbine arranged to burn methane gas

Traffic Improvements for New York

(By Our American Correspondent)

A LONG overdue attempt to develop a comprehensive, integrated plan for the smooth and uninterrupted flow of traffic into, out of and through the New York-New Jersey metropolitan area is finally being made. The Port of New York Authority and the Triborough Bridge and Tunnel Authority have joined forces to study the complex problem, and the aim of the new joint approach is a highway system that will make it possible for the great volume of through traffic that has no business and no desire to be in New York City to speed around, under and over local traffic without getting tangled in it. Paradoxically, every new highway, bridge and traffic improvement attracts more and more cars. Reducing it to its simplest form, the problem in New York is to find ways of maintaining a free flow of traffic, and of diverting through traffic between the outlying areas from metropolitan streets which are already jammed to the kerb with local pleasure and commercial vehicles. New York's arterial traffic problem has been growing faster than the increased use of motor vehicles in the city. Facilities which, it was believed only three years ago, would not be needed until after 1960, are essential now if local streets are to be saved from traffic strangulation and the pressures relieved on the vast but inadequate network of arterial highways in this region. The two authorities have taken an important step forward in pooling their knowledge. They have retained several leading consulting engineers to develop an integrated master plan that will aim to combat congestion during the years immediately ahead. It has been said that engineers can construct anything people are willing to pay for, but the very practical directors of the authorities have laid down a hard and binding restriction : no project will be advanced that cannot be made self-supporting. Within that framework the consultants are now investigating the following schemes : (1) A second level for the George Washington Bridge ; (2) a new bridge to span the Hudson River between 125th Street in New York and the Fort Lee-Cliffside Park area of New Jersey ; (3) a midtown " expressway," either elevated or a tunnel, to link the Lincoln Tunnel and the Queen's Midtown Tunnel ; (4) an elevated " expressway " across Broome Street in Lower Manhattan to connect the Holland Tunnel with the Manhattan Bridge and the Williamsburg Bridge over the East River ; (5) a high-level bridge connecting Brooklyn and Staten Island over the Narrows, which is the main channel used by ships entering or leaving New York Harbour.

The fixed crossings proper are the least of the problem. The more important issue is to provide an approach system not only for the new facilities themselves, but to tie them into other arterial schemes constructed or scheduled to be completed in the next few years. It is a lamentable fact that several of the big and costly traffic improvements which now dot the metropolitan area are responsible for bottlenecks that sometimes must make many a car owner wish they never had been built. To any irritated motorist who has inched painfully from the New Jersey Turnpike exit at Secaucus to Manhattan through the Lincoln Tunnel it is obvious that the third tube of that crossing now under construction should have been ready five years ago. However, it will not be completed until 1957, and meanwhile snail-pace travel will continue. The authorities have pledged that any public projects arising from the present study will be supplementary to, and carefully co-ordinated with, the existing highway systems. They want to avoid the costly mistakes of the past which have resulted from various agencies " going it alone " and providing new facilities without regard for the overall welfare of the users of the highways, bridges and tunnels concerned. To-day at least 25 per cent of all traffic using the existing trans-Hudson crossings does not want to come into middle and lower Manhattan. Much of it is truck traffic travelling between New Jersey, Southern New England and Long Island. At present it must battle its way between the Hudson and the East Rivers across snarled local streets. More than 55 per cent of weekday travel and 70 per cent of Sunday travel over the George Washington Bridge and through the Lincoln and Holland Tunnels does not start or end in Manhattan. The authorities contend that the needs of these travellers can be met by some combination of the proposed Narrows Bridge, a second deck for the George Washington Bridge and a new span situated 2½ miles south of the latter structure.

For nearly fifty years the Narrows Bridge has been a dream of local planners, and twenty-five years ago a start actually was made on a crossing under the Narrows between Fort Hamilton on the Brooklyn shore and Fort Wadsworth on the Staten Island side. At that time the plans called for a tunnel, the U.S. Army having rejected a bridge. However, four years ago the U.S. Army Corps of Engineers approved plans submitted by the Triborough Authority for a 4600ft long structure to connect the two boroughs. It would be the longest suspension bridge in the world, 400ft longer than the Golden Gate Bridge at San Francisco. Although the Triborough Authority has Federal approval, it cannot finance the bridge until after 1957 because of existing commitments to its bondholders. However, it is considered possible that the Port Authority might build the bridge and lease it to the Triborough Authority. But even more important than the bridge is the matter of connections. On the Brooklyn side an approach system costing as much as 100 million dollars might be necessary to obtain full benefit from the new crossing. On Staten Island a long " expressway " from the bridge plaza would have to be constructed. And even though the study is only a few weeks old, loud objections are already beginning to be heard. Staten Islanders see a bridge destroying their rural way of life. In Brooklyn the cry is that the bridge would make a wide and permanent scar through fine residential districts, destroy much valuable property and wipe out historic churches and other landmarks. These problems are typical of those with which the consultants are now faced. It is to be hoped that the integrated development of New York's traffic system will not be jeopardised by such reasoning, for the need for highway and related improvements was never greater. Only a few years ago official estimates stated that by 1960 some 69,000,000 vehicles would pass into, out of and through the city. But in 1953—seven years short of 1960—already more than 73,000,000 used the existing facilities in the metropolitan area and the estimate for 1960 has now been advanced to 95,000,000 vehicles !

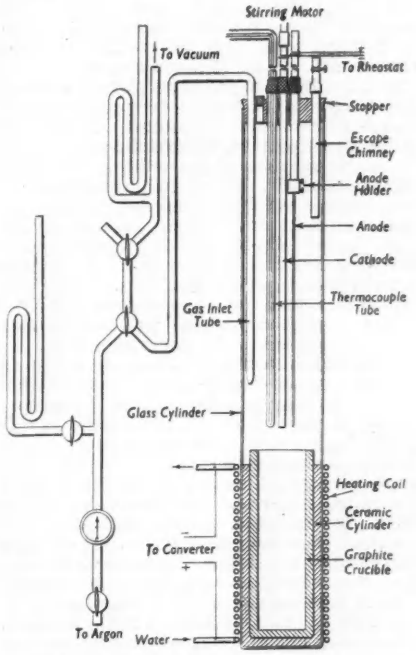
American Engineering News

(By Our American Correspondent)

Electrolytic Preparation of Molybdenum

A research programme sponsored by the U.S. Army Ordnance Corps, has resulted in the successful electrolytic preparation of molybdenum at the National Bureau of Standards. The experiments involved have produced high-purity molybdenum by electrolysis of a bath of fused salts. The process used has been found to be very flexible and easily controlled and depending on the conditions of electrolysis, the deposits vary from fine powders to thick, coherent layers. It is believed that with further development of the process the electro-forming of molybdenum objects may become feasible. This, in turn, would result in more rapid, less expensive methods for producing molybdenum parts and coatings and for extracting the metal from the ore.

In recent years the need for heat-resistant materials in various applications has stimulated



Apparatus for electro-deposition of molybdenum

interest in refractory metals such as tungsten and molybdenum. At present molybdenum is generally produced chemically as a fine powder by reducing purified molybdic oxide with hydrogen. The process involved is expensive and has a number of other disadvantages. The molybdenum is obtained as a very fine powder, and the size of the particles cannot be controlled. Because of the fineness of the powder, a large surface area is exposed to oxidation, and extensive purification is thus required. Complicated powder-metallurgical procedures are also necessary to fabricate the powder into molybdenum parts. These disadvantages may be eliminated by the electrolytic method, as the deposits are obtained directly on the cathode in the desired physical form and in a very pure state. Thus, electro-forming would make possible the formation of molybdenum parts having complicated shapes. Electroplating of molybdenum would have the advantage of conserving this critical metal and, at the same time, would allow the designer to take advantage of the properties of the base metal.

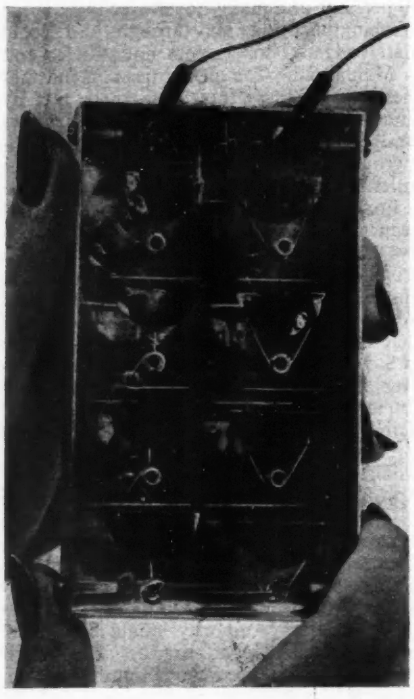
The work on molybdenum at the Bureau was part of a general programme of research which is being conducted in an effort to develop methods for electro-depositing in good physical form metals such as tungsten, titanium and zirconium, which have not been deposited from aqueous solutions. Some time ago, this programme resulted in a practical process for electro-depositing aluminium from an organic plating bath at room temperature. The work on molyb-

denum began with an investigation of compounds representative of the stable valency states of the metal; each was studied with regard to its suitability for use in the electrolytic preparation of molybdenum from fused salts. Ultimately, satisfactory results were obtained with solutions of potassium hexachloromolybdate K_3MoCl_6, in molten mixtures of alkali halides. Coarse powders of pure molybdenum were deposited on the cathode from a solution of K_3MoCl_6 in a 1 : 1 (by weight) mixture of sodium and potassium chlorides at a temperature of 900 deg. Cent. and current densities of 3A to 100A per square decimetre. When a eutectic mixture of potassium and lithium chlorides was used at the same current densities and at temperatures between 600 deg. and 900 deg. Cent., the deposits varied in form. At 3A per square decimetre and 600 deg. Cent. the deposits were thick, coherent layers while at higher temperatures and current densities fine powders were produced. For both solutions the optimum concentration of the molybdenum salt was about 4 mol per cent. It was discovered that contamination by oxy-compounds resulted in a low current efficiency and impure deposits. All materials were therefore dehydrated carefully before use, and the electrolyses were carried out in an argon atmosphere. The apparatus shown in the accompanying diagram was designed to permit high-temperature operation with automatic temperature control, the external manipulation of the electrodes, and the automatic agitation of the cathode. A water-cooled induction furnace coil surrounded the lower third of a "Pyrex" cylinder 18in long and closed at the bottom. Inside the lower third of the "Pyrex" tube was placed a ceramic cylinder, and within the ceramic was a machined graphite crucible containing the fused salts. The top of the glass cylinder was sealed with a rubber stopper containing openings for the electrodes, a thermo-coupled tube, a connection to the gas system, and an escape chimney. A rod ¼in in diameter and 2ft long was inserted through one of the holes to serve as the cathode. It was connected at the top to a variable-speed stirring motor by a tightly fitted rubber coupling. A soluble anode of pure commercial molybdenum sheet was used. If an insoluble anode is used a diaphragm is required to separate the anolyte from the catholyte. Both electrodes were immersed to a depth of about 3in. The furnace was supplied with power by a mercury spark gap converter, which was controlled by a Chromel-Alumel thermo-coupled and a controlling pyrometer placed in the input circuit of the converter. The heating rate of this unit was rapid, the melt reaching a temperature of 900 deg. Cent. in about ten minutes.

The melting procedure began with the purification of the alkali chloride mixture. This was done by fusing it in the graphite crucible at a temperature a few hundred degrees above its melting point and allowing it to cool in an inert atmosphere. The "Pyrex" vessel was then opened and the previously dried molybdenum compound was quickly added on top of the solid halide solvent. The system was evacuated and flushed out with argon. Heating was then begun, and at the desired operating temperature the electrodes were inserted into the melt. The flow rate of the argon was set at any value between 200 and 3000 c.c. per minute, and the outlet chimney was always adjusted to maintain a pressure slightly above atmospheric inside the system at all times. When very hygroscopic material, such as lithium chloride, was present, the bath was heated to 900 deg. Cent. at the same time as the argon flow was increased to about 3000 c.c. per minute. This procedure rapidly drove out any released moisture and volatile oxy-compounds. The deposits adhered well to the cathode and were easily separated from the adhering electrolyte by leaching with dilute hydrochloric acid. Deposits from both the solutions used were found to be more than 99·9 per cent molybdenum and to contain as little as 0·026 per cent oxygen. The density of the coherent deposits was 9·6, or 94 per cent of the theoretical density of molybdenum. The current efficiency in metal deposition was 100 per cent in both solutions over the full range of current density. During the investigation improved methods for the preparation of K_3MoCl_6 and of molybdenum dichloride $(MoCl_2)_x$ were developed. In the preparation of the hexachloromolybdate, potassium molybdate was dissolved in hydrochloric acid, and the solution was electrolysed in a divided cell. Hydrogen chloride was then added to the catholyte to precipitate the K_3MoCl_6. The molybdenum dichloride was obtained by first reducing the pentachloride with molybdenum powder to the trichloride, which was then heated to produce the dichloride by thermal dissociation.

Experimental Solar Battery

On April 25th the Bell Telephone Laboratories announced the development of a method for the direct conversion of small, but usable, quantities of solar energy into electricity. At a demonstration of the device in the grounds of the laboratories at Murray Hill, New Jersey, the experimental solar battery was used to power a wireless transmitter utilising transistors and also as a source of electrical energy for a conventional telephone communications circuit. The battery, which is shown in



Experimental solar battery

the accompanying illustration, is made up of thin wafers of specially prepared silicon and its working is based on the function of the so-called "*p–n* junction." The individual wafers may be linked together electrically and can deliver power from the sun at the rate of 50W per square yard of surface. It is well-known that *p–n* junctions, when introduced into single germanium crystals, also form the basis of the junction transistors.* The particular electrical properties of the solar battery depend on the substitution of silicon for germanium as the crystalline material in which *p–n* junctions are made by the controlled introduction of traces of impurities. The origin of the present device has been traced back to at least the first decade of the century when semi-conducting crystals provided a popular wireless detector. As radio frequencies have moved persistently upward of late, the vacuum valve has lost its original advantage and it has been realised that the original erratic "crystal detector" could be made reliable and reasonably efficient, and that it was capable of taking a leading part in extending the useful frequency range to higher and higher limits. In the resulting intensive study of crystal detectors at the Bell Telephone Laboratories, the silicon to which the metal point has been applied was found to be "spotty," indicating non-uniformity in the material when available. Although these impurities could not be detected chemically, efforts were made to remove them. It was found that a careful freezing of silicon starting at the top of the melt and working slowly downward, segregated the impurities so that a considerable part of the ingot would be uniformly satisfactory for use in micro-wave detectors. It was discovered, however, that this process automatically produced in such ingots the first known *p–n* junctions. They were imperfect and inefficient, but were, nevertheless, the prototypes of all of to-day's junction devices. The Bell group identified the *p* type impurity as boron and the *n* type impurity as phosphorus, and went on to make the first synthetic *p–n* junction by deliberately adding these impurities to molten silicon and by diffusing them into solid silicon. The resulting junctions were of considerable scientific significance, and further work in this field showed that other elements whose electronic structures resembled boron and phosphorus behaved similarly when added to silicon as impurities.

Early work with germanium transistors led to the belief that *p–n* junctions built into very pure single silicon crystals would perform many functions for which germanium was not well suited. Among them were applications involving computers and switching elements, solar energy conversion, and all kinds of transistor action involving higher temperatures. The initial step in the development of silicon transistors was to grow single silicon crystals. The second step of adequately purifying silicon proved very difficult, since it is chemically much more active than germanium. Careful fractionation, including distillation of silicon derivatives, finally led to an unexcelled purity of the element. Thanks to the co-operation of the DuPont Company, which had already been active in silicon chemistry, a sufficient volume of silicon for the present experiments was obtained. It was then found that a further understanding of the physics of electrical processes in semi-conductors was required before satisfactory silicon transistor devices could be made. The important step of building *p–n* junctions into the silicon crystal has been accomplished in a variety of ways. Early *p–n* junction rectifiers were made in silicon by welding aluminium wires on it. The small area junctions thus formed have been found to be very suitable for low-current computer applications. More recently, special crystal-growing techniques have been employed for the successful construction of silicon transistors. These transistors now have most of the desirable properties of the earlier germanium devices and, in addition, can operate well at high temperatures. The latest technique in this field, which has been used successfully in connection with various silicon devices, consists of the preparation of *p–n* junctions by diffusing impurities into the surface of a silicon wafer. The process used involves the heating of the semi-conductor wafer in the presence of a suitable impurity vapour. In this way, *p* or *n* type layers of controlled thickness are formed just below the semi-conductor surface. The method has been used for both large area, high-power devices and for devices with more complicated geometries where exceedingly small dimensions are required. Using such "diffusion junctions," successful high-power rectifiers and lightning arrestors have been made, and the latest application of these junctions is in the making of the large area solar batteries.

In using the experimental solar battery, it has been reported that a 6 per cent efficiency was obtained in converting sunlight directly into electricity. With improved techniques, it is expected to increase this efficiency substantially. Nothing is consumed or destroyed in the energy conversion process and there are no moving parts, so that the Bell solar battery should theoretically last indefinitely. Although the current work is still at the laboratory stage, the actual use of the solar battery in the telephone system is believed to be a strong possibility. For example, silicon solar batteries might be used as power supplies for low-power mobile equipment, or as solar-powered battery chargers which could be used at amplifier stations along a

* American developments in the field of junction transistors were described in THE ENGINEER, June 26, 1953, page 886.

rural telephone system such as that now under trial at Americus, Georgia.

Measurement of Screw Thread Pitches

A method recently developed at the National Bureau of Standards permits the rapid measurement of the pitch, or lead, of internal screw threads without sacrificing the high accuracy usually required in this work. The method can be used to determine the taper of ring gauges at the same time as lead and is adaptable to measurements in very small ring gauges, which had in the past proved difficult. For straight-thread ring gauges, the technique has the added advantage that the straightness of the bore can be determined simultaneously with measuring the lead, thus providing a quick assessment of the amount of wear at the ends of the gauge.

In connection with the programme of the American Petroleum Institute for standardisation of the threaded connections on oil field equipment, the National Bureau of Standards calibrates the master thread gauges used by the American petroleum industry for the calibration of working standards. This is done through the use of thread measuring instruments whose calibration is ultimately based on the national standard of length maintained by the Bureau. Because the standardised A.P.I. threaded joints cover such an extensive range of sizes—¼in to 20in in diameter and up to 6in of threaded length—the measurement of some elements of the threads is beyond the range of commercially available measuring equipment, and the National Bureau of Standards and the manufacturers of A.P.I. gauges have had to design special equipment for this purpose. Until now, such equipment for the determination of the lead had required the use of two series of equal combinations of gauge blocks for the measurement of the intervals, and the procedure involved had been rather time consuming. The more rapid method now developed for measuring the lead makes use of a taper testing machine constructed by Pratt and Whitney. This device consists primarily of an adjustable sine plate on which the gauge to be tested is mounted, and a carriage which travels on accurately machined ways to move a ball-point probe in and out of the mounted gauge. When the angle between the sine plate and a normal to the plane of the ways is equal to one-half the taper angle of the gauge under test, the pitch line at the bottom of the gauge (provided the taper of the gauge is straight) will be parallel to the ways. As the carriage moves along the ways, the small ball on the end of the probe contacts the flanks of the threads in the ring gauge. If the taper of the gauge is true, the ball will remain at the same elevation above the ways as the probe moves from thread to thread. Any variations in the elevation of the probe, caused by errors in the taper, are read on an electrically actuated meter.

The National Bureau of Standards has extended this procedure to permit the use of the same settings of the probe to determine lead as well as taper. The method for lead determination involves the measurement of the movement of the carriage through the use of a glass scale graduated in increments of 0·050in over a range of 4in. The glass scale moves with the carriage, and the position of the scale is observed with a Hilger and Watts microscope having four reticule graduations, each equivalent to 0·01in on the scale. A scale graduation is brought into apparent coincidence with the nearest reticule graduation by rotating a plane parallel plate of optical glass in the optical path of the microscope. This parallel plate constitutes an "optical micrometer," and the shaft on which it rotates carries a graduated drum having 200 divisions for each 0·01in of apparent motion of a scale graduation. This gives a least reading of 0·00005in and permits the estimation of fifths of divisions. The scale is accurate to ±0·00002in in 1in and ±0·00004in in 4in. For the accurate measurement of lead, the motion of the carriage must be substantially free from friction. This is accomplished by having the carriage roll on ¼in steel balls situated in suitable guides. The lower surfaces of these guides are formed by two parallel V-grooves, approximately 3¼in apart and running along the entire upper surface of the base on which the carriage travels. The corresponding upper surfaces of the two guides are formed by a single V-groove and a flat surface which run along the underside of the carriage. By viewing a mirror mounted on the carriage with an auto-collimating telescope, it is possible to determine any deviations from the linear motion of the carriage quite accurately and to make such adjustments of the ways as are necessary to obtain practically straight line motion of the carriage. The modified instrument has proved highly satisfactory for the rapid, accurate measurement of the lead of both straight thread and tapered ring gauges. Special probes have been used for the measurement of very small thread ring gauges. The instrument has also been used to measure the lead of thread plug gauges up to 3in in diameter. In general, the repeatability of the readings has been found to be as good as the precision with which the scale can be read, i.e. between 0·00001in and 0·00002in.

Nuclear Reactors for Industry

The progress which has been made of late in the field of industrial applications of atomic energy is illustrated by the appearance in America of what has been called the first atomic pile "catalogue." The publication has been issued by North American Aviation, Incorporated, of Downey, California, and describes a line of research reactors which the company is prepared to design and build for qualified scientific and industrial groups, subject to the approval of the U.S. Atomic Energy Commission. Three fundamental designs of reactors are described in the catalogue, which is entitled "Nuclear Reactors for Science and Industry." These are the solution, the pool, and the homogeneous graphite reactors which can be used as the basis for pile designs to meet specialised nuclear research requirements. The solution reactor is a machine in which the fissionable material is contained in a water solution in the core. These reactors are referred to as "water boilers" because of this arrangement, although there is no actual boiling of water. The power rating for the solution reactor offered is 50kW. Operating under water, the pool reactor is rated at 100kW to 1000kW and is the largest reactor design offered. The core of this reactor consists of highly enriched uranium and aluminium alloy. Finally, the homogeneous reactor, which is rated at 160kW, incorporates a core of graphite and enriched uranium. The different designs of reactors are suitable for various specialised requirements for obtaining high neutron and other radiation production in atomic research and are not designed to generate electric power. Although power ratings for the machines are given in kilowatts, this reference is only a means of identifying the energy level at which the reactors operate to produce the required radiation results.

North American Aviation has been active in the atomic energy field since 1946, when studies began in fundamental nuclear research. Since 1948 the company's Atomic Energy Research Department has been working on nuclear projects under contract with the U.S. Atomic Energy Commission. In 1952 the company designed and built a water boiler reactor which is being used at the Downey works in connection with atomic energy research and reactor designs. The latter unit was the first reactor to operate in California, and was followed recently by the second reactor in the state, also built by the company. The latter reactor is also a water boiler and is being used for materials research at the California Research and Development Company in Livermore, under contract with the A.E.C.

The company's standard solution reactor produces a high-flux source of neutrons at minimum cost and with minimum fissionable material. This type of reactor has proved to be highly satisfactory as a general-purpose reactor. Solution reactors for research have been designed and operated at power levels ranging from less than 1W to approximately 40kW, and present design studies show that a 50kW reactor can be readily constructed and placed in operation. The core of the 50kW reactor consists of a 1ft diameter stainless steel sphere containing approximately 14 litres of enriched uranium sulphate solution. The core is surrounded by a graphite reflector 2ft thick and is cooled by refrigerated distilled water passing through stainless steel coils within the sphere. A closed-cycle system recombines the products of water decomposition and returns them to the core; the same system provides for the removal of gaseous fission products. The concrete shield is shaped to present eight faces at which test facilities can be installed. Where high intensities are not required a milliwatt solution reactor may be used as a neutron source. No cooling is required at this power level and disposal of the evolved gases can be accomplished by accumulating them in an auxiliary cylinder. This reactor can be manufactured at minimum cost because of its simple design. The following specifications apply to the 50kW solution reactor :—

Details of Solution Reactor

Rated sustained power ...	50kW
Total excess neutrons	$1{\cdot}5\times10^{15}$ neutrons per sec
Available slow neutron flux	2×10^{12} neutrons per sq. cm-sec
Available fission energy :	
Neutron flux	2×10^{12} neutrons per sq. cm-sec
Critical mass	750 grammes
Coolant...	Light water
Gas handling	Closed cycle, water recombination and return
Fuel cycle time	Solution readily added as required
Diameter (with shielding) ...	18ft
Height	16ft

The pool reactor designed by the company is recommended for experiments and investigations requiring maximum neutron flux. This reactor is capable of operating at power levels up to 1000kW, which corresponds to a thermal neutron flux of 10^{13} neutrons per square centimetre-sec. This reactor uses a heterogeneous core of plate fuel assemblies of highly enriched uranium and aluminium alloy. The fuel-bearing portion of the core can be surrounded by reflector assemblies. The entire reactor core is immersed in a pool of high-purity water which serves as moderator, coolant and shield. In this particular reactor the water shield encloses a heterogeneous core; such a water shield can also be used with the solution core or the homogeneous core. A cooling system is essential for sustained operation at 1000kW, but may be omitted for lower power and intermittent operation. Operational access to the reactor is facilitated by appropriate walkways and a movable bridge situated above the surface of the pool. The pool reactor is the most flexible of all research reactors, being easily adaptable to changing experimental requirements. Samples of any size can be placed conveniently at any position within the pool. Individual fuel assemblies can be removed for high-intensity irradiations within the core. The high neutron and gamma-ray fluxes available with this reactor facilitate the performing of radiation damage experiments. Furthermore, highly collimated neutron beams can be provided for neutron diffraction and time-of-flight studies. The following specifications apply to the pool reactor :—

Details of Pool Reactor

Rated sustained power ...	100kW to 1000kW
Total excess neutrons... ...	3×10^{5} to 3×10^{13} neutrons per sec
Available slow neutron flux	10^{12} to 10^{13} neutrons per sq. cm-sec
Available fission energy neutron flux	5×10^{11} to 5×10^{12} neutrons per sq. cm-sec
Critical mass	3kg
Coolant...	Light water
Gas handling	None (clad fuel elements retain fission products)
Fuel cycle time (probable) ...	9,000,000kWh
Pool diameter	10ft to 35ft (depending on pool walls)
Pool depth	20ft

The homogeneous graphite reactor of the firm is recommended for applications involving a maximum of experimentation or simultaneous irradiations. Because of the large volume of the reactor core, many test facilities may be brought to the position of maximum neutron flux and a large number of simultaneous irradiations may be made with a minimum effect on reactivity. The core of this reactor consists of a homogeneous mixture of graphite and enriched uranium. This mixture combines the advantages of the homogeneous type of reactor (in particular, the large negative temperature coefficient of reactivity) with the advantage of a solid, sealed core. The core unit is not penetrated by any test facilities, and all fission products are permanently sealed in the tank during the operating life of the core—thus no handling or disposal problem exists. No fuel additions are

made ; at the end of the core cycle the core is replaced as a unit. The following specifications apply to the 160kW homogeneous graphite reactor :—

Details of Graphite Reactor

Rated sustained power ...	160kW
Total excess neutrons	5×10^{17} neutrons per sec
Available slow neutron flux	2×10^{13} neutrons per sq. cm-sec
Available fission energy neutron flux	2×10^{13} neutrons per sq. cm-sec
Primary coolant	Heavy water
Gas handling	None (sealed core retains fission gases)
Fuel cycle time	3,500,000kWh
Diameter (including shielding)	19ft
Height (including shielding)	11ft

It is expected that these piles will find applications in science and industry as low-cost neutron sources for general research purposes, as sources of neutron beams for medical or biological use, for the preparation of radioactive chemicals or short-lived isotopes, such as the 14·8-hour Na^{24} and the 37-minute Cl^{38}, and as a training and research facility around which a nuclear engineering curriculum may be built.

Extrusion of High-Alloy Steel Tubing

The Tubular Products Division of the Babcock and Wilcox Company, of Beaver Falls, Pennsylvania, is now using the Ugine-Sejournet hot extrusion process to produce seamless tubing in a limited size range in the American " Uniloy 19–9DL " alloy. At present this alloy is most commonly used in jet engines, experimental aircraft and gas turbines. It has exceptionally good strength at temperatures up to 1200 deg. Fah. and has been used successfully at somewhat higher temperatures for certain applications. " Uniloy 19–9DL " is a predominantly austenitic stainless steel containing chromium, nickel, molybdenum, tungsten and small quantities of columbium, tantalum and titanium. It is corrosion resistant, having characteristics similar to high-carbon, 18 per cent chromium, 8 per cent nickel stainless steels. It has been shown that 19–9DL has oxidation resistance superior to other austenitic stainless steels of its own class. Tests conducted at 1200 deg. Fah. have indicated the comparative oxidation resistance to be as follows :—

Steel	Oxidation rate-inches of penetration per year
Uniloy 19–9DL	0·0008
A.I.S.I. 309	0·0030
A.I.S.I. 317	0·0017
A.I.S.I. 446	0·0001

A.I.S.I. 446, a ferritic steel having 27 per cent chromium content, shows superior oxidation resistance, but is rather brittle and is susceptible to shock when cold. The 19–9DL analysis, however, is tough at both room and elevated temperatures. At 80 deg. Fah. tests have shown the Charpy impact strength of 19–9DL to be in the neighbourhood of 46ft-lb and at 1200 deg. Fah. about 56ft-lb.

The strength of 19–9DL is further demonstrated by its stress rupture and creep values. Tests at 1200 deg. Fah. show the stress to rupture at the time periods indicated to be :—

Time to rupture	Stress
10 hours	50,000 lb per square inch
100 hours	44,000 lb per square inch
1000 hours	37,000 lb per square inch
10,000 hours	31,000 lb per square inch

Similarly, the stress for secondary creep rates is as follows :—

Creep rate	Stress
0·01 per cent per 1000 hours ...	9,800 lb per square inch
0·10 per cent per 1000 hours ...	19,500 lb per square inch

Since there is considerable equipment of which seamless tubing is a part operating under conditions involving high stresses and temperatures, it is believed that applications of the new alloy will now be expanded. Babcock and Wilcox was the first company in America to take full advantage of the French hot extrusion process, which is now also being applied to metals such as titanium which are difficult or impossible to manufacture into tubing by rotary piercing.

ALUMINIUM ALLOY BROCHURE.—We have received from T.I. Aluminium, Ltd., a brochure which deals briefly with aluminium alloys made by the company. The various alloys are ordered in numbered groups and a tabular statement gives particulars of the heat treatment of certain of the alloys, while in the following pages the mechanical properties and related specifications of sheet, strip, bars, sections, tubes and plate are listed. A separate table sets forth the chemical composition of the company's alloys.

East African Radio-Telephone Link

AN important addition to the communications system of East Africa has recently been made with the completion of a v.h.f. multi-channel radio link between Nakuru in Kenya and Jinja in Uganda. It gives an immediate increase of twelve channels to the four already available between Nairobi and Kampala with provision for twelve more in 1955 and another twelve when traffic demand justifies their introduction. Stand-by equipment allows for thirty-six alternative speech circuits to be automatically available in the event of breakdown or deterioration of those in use, while a separate engineering speech channel is included in both " A " and " B " routes to facilitate testing and co-operation in the clearing of faults.

The radio system links the terminal points of the existing land line circuits between Kampala and Jinja (52 miles) and Nairobi and Nakuru (98 miles). The latter link replaces a Marconi v.h.f. multi-channel link, with repeaters at Ngong and Eburru Mountain, which was installed mainly for experimental purposes in 1949 and was used successfully for three years. It was the first of its kind in the Commonwealth outside the U.K.

It is now nearly three years since planning and survey of the Nakuru–Jinja route was begun by the staff of the Engineer-in-Chief's office of the East African administration in consultation with Marconi's, resulting in the selection of four repeater station sites—at Loldiani, 30 miles north-west of Nakuru ; Gemba, 105 miles west-south-west of Loldiani (10,000ft) ; Lugulu, 40 miles north of Gemba, and at Nasu Point (4400ft), a short distance south of Jinja and 55 miles west of Lugulu. No access roads existed in the first place to any of these mountains ; Loldiani was isolated by virgin bamboo forest, and Gemba was approachable only by black cotton-soil tracks across the Lambwe Valley, which were liable to become impassable in wet weather. Since 1953, when the work began, the construction of these repeater stations has involved the building of seven bridges and 12 miles of road, much of it blasted or cut into and across mountain sides, with gradients in places as steep as 1 in 3. Actual building began in January of this year, involving the transport by truck of up to 300 tons of material to each site. Much of the equipment had to be dismantled and taken up from base camp to site piece by piece for reassembly.

The system operates in the 180–210 Mc/s frequency band and power is provided at each repeater station by duplicated diesel alternator equipment, each set running for forty-eight hours, with automatic changeover and alarm facilities. Any radio fault is reported automatically by alarm sounded simultaneously in Jinja and Nakuru.

This link between Nakuru and Jinja is part of the scheme which provides for similar thirty-six channel links between Mombasa and Tanga and Mombasa and Nairobi. The equipment for these links is being provided by Marconi's Wireless Telegraph Company, Ltd., Chelmsford, Essex.

Ferrous Scrap Recovery at Pitsea

RECENTLY we visited what is probably the largest refuse tip in this country at Pitsea, Essex, where pilot plant for the recovery of ferrous scrap from dustbin refuse has recently been installed. The land reclamation scheme operating in this neighbourhood was started some eighteen years ago, and upon the site some 150,000 tons of dustbin refuse from nine of London's major boroughs is distributed annually from river barges. It is laid, consolidated and finally covered with a carpet of soil, and already some areas are under cultivation.

As it is estimated that some 4 per cent of this refuse is composed of ferrous scrap—most of it tin cans—the British Iron and Steel Federation suggested that a scrap recovery scheme be investigated. This scheme has been undertaken by the New London Electron Works, Ltd., which operates a plant at its factory in Stepney for the recovery of tin from cans.

DESIGN CONSIDERATIONS

The barges at Pitsea are discharged at eight different points at the site, each being provided with a grab crane of 3·5 cubic yard capacity and a cycle time of about one and a half minutes. Consequently, the pilot equipment installed was designed to accommodate this rate of discharge, with the intention of erecting a similar plant at each discharge point. This capacity was also more in keeping with the electrical components commercially available and minimised the problems associated with the foundations on such a site. Other economic factors, however, have not yet been fully investigated and it is possible that larger installations may prove more profitable. The present plant requires a team of eight men and its capacity is about 35 tons per hour from which it is expected to recover about 4 tons of tins per day. The total current consumption is about 35kW.

OPERATION

At its lower end is the receiving hopper which measures 16ft by 14ft and discharges on to an apron conveyor 6ft wide and 15ft long. It is driven by a 4 h.p. motor at 10ft to 15ft per minute.

From this belt refuse is deposited on to an inclined belt conveyor running at 130ft per minute, the belt being 32ft long by 5ft wide, and driven by a 7 h.p. motor. The level of the carpet is manually adjusted to ensure maximum exposure of the cans to two magnet units situated near the upper end of the belt. These units are " Overband " electromagnetic separators supplied by Electromagnets, Ltd. Each separator consists of a stationary magnet mounted on a channel framework around which an endless belt revolves, fitted with soft iron poles. The field of each unit extends over slightly more than half the belt width. Each unit is fitted with a rectifier and is driven by a 3 h.p. motor.

As the cans approach the magnet they are lifted out of the carpet, rise to the " inducer " belt, and travel with it across the conveyor to a vertical chute alongside, down which they drop into bins.

These are mounted on a gravity track fitted with two overhead cranes, the system allowing the full bins to be loaded on to lorries from one end, whilst empty bins are unloaded from lorries at the other end. The refuse remaining is discharged from the conveyor directly into lorries to be tipped and consolidated on the site, where it finally shrinks to one-third of its original volume.

The whole separation unit is mounted upon a wheeled carriage and can travel along a rail track, a distance of 30ft, to accommodate the reach limits of the crane jib.

Technical Reports

S.S. " Ocean Vulcan " Sea Trials : Detailed Analysis of Record No. 6.E.7. (Loaded Condition) : Report No. R.10. Admiralty Ship Welding Committee. H.M. Stationery Office. Price £2 2s.—This report gives the detailed analysis of one of the more important records taken during the sea trials on S.S. " Ocean Vulcan," when the ship was fully laden. The general condition of loading of the ship and of the seaway which applied at the time, are given together with extracts from the field data and a brief discussion of their significance. Some of the more interesting cases selected from the detailed analysis are published in full in order to show the magnitude of the acceleration and bending moments, the variations in hydrostatic pressure and other actions along the length of the ship. An estimate of the probable accuracy of the results is made.

Envelope curves are given to show the maximum values of bending moment, &c., which were recorded along the length of the ship, and an investigation has been made to ascertain the combinations of the various actions which cause the highest stress amidships. This report should be read in conjunction with Report R.8, which describes fully the nature of the trials.

The Use of Fire-Resistant Timber in Mines. Information Bulletin No. 54/106. London : National Coal Board, Hobart House, Grosvenor Place, S.W.1—This bulletin is concerned mainly with the fire-resistant properties of treated timber in coal mining and the methods and cost of treatment. Two well-known methods of treatment—impregnation and the application of a surface coating—are described and compared.

Industrial and Labour Notes

National Production Advisory Council

The Chancellor of the Exchequer, Mr. R. A. Butler, addressed a meeting of the National Production Advisory Council, which was held in London on Friday last. In his speech, Mr. Butler said that the notable economic fact about 1954 so far was that, in spite of the fall in industrial activity in the U.S.A., trade and production outside the dollar area had gone on rising. Between July, 1953, and April, this year, United States industrial production fell by 10 per cent, but in the same period the sterling area gold and dollar reserves rose by 19 per cent.

The Chancellor went on to say that, so far as the United Kingdom was concerned, the export figures for the first four months were higher than in either half of last year, and the fiscal year had begun with a much smaller trade gap. Engineering exports, which lagged a little last year, were picking up, and although exports to North America in the first few months of this year were about 10 per cent lower than a year ago, non-sterling exports were higher. Therefore, the Chancellor continued, although the value of this country's export trade was not quite as high as in the boom quarter at the beginning of 1952, it was much better balanced.

About home production, the Chancellor said that the first few months of this year had provided a succession of cheering percentages, total industrial production being 7½ per cent higher than in the comparable period of last year. But, he added, the faster we modernised and expanded our productive capacity, the more we should be able to increase the national wealth. In conditions of full employment there was no need to be afraid of investing too much or of producing too much. Nor was there any need to fear that modernisation and increasing efficiency would create unemployment. It was essential, the Chancellor emphasised, to keep prices stable in order to hold on to our share of world markets and to avoid strains and dislocations at home. He thought we were probably entering a period when it would be more difficult to keep prices from rising, and it was therefore a matter for both sides of industry to see that increased money returns, either dividends or wages, were matched by increased output.

Conference on Work Study

Last weekend a conference on work study was held at Harrogate. It was arranged by the British Institute of Management and the British Productivity Council, and was attended by over 800 industrialists. The general principles, scope and various applications of work study were expounded by a group of thirty directors, managers and work study specialists from Imperial Chemical Industries, Ltd.

The Minister of Labour, Sir Walter Monckton, Q.C., addressed the conference on Friday last. He said that work study had been described as the ordering of common sense. Many industries had been applying work study principles to various aspects of their activities for a very long time. Indeed, this country had led the world in many branches of science and technology because research and development had been planned on orderly lines. But, Sir Walter commented, it was necessary to bring the same order, the same critical and analytical approach to an increasing range of problems in industry, and he hoped it would be carried right through and applied to all the problems of management and human relations. If we were to prosper, Sir Walter continued, ways must be found of bringing the standards of practice in all firms, large and small, as near as possible to the level of the best. The sooner that could be accomplished, the sooner, he believed, we should be able to make a really big advance in productivity. Sir Walter said that he welcomed particularly the advent of the work study unit which had been formed by the British Productivity Council. He hoped it would create a wider understanding of the value of work study throughout all levels of industry and that it would make a particular impact on sn aller firms, dispelling some of the fear that was always associated with the unknown and demonstrating the benefits which work study could confer.

On Saturday, Sir Ewart Smith addressed the conference on " Work Study and Management." He urged that management should normally be a dynamic function and not, as was all too often the case, one of keeping things running on existing lines. Nowhere was forward-looking and effective management more needed than in the application of modern techniques such as work study. Neither work study nor any other technique, Sir Ewart said, could be effective unless there was proper understanding of its potentialities and limitations, and consequently management itself had to be educated in work study before work study could be effectively applied. Sir Ewart went on to stress the necessity of bringing the trade unions into the picture at the earliest possible moment, and said that in such discussions there must be no hesitation to face all the problems involved. The basic principle of finding and stating the facts must apply, otherwise there could be no real understanding or permanent confidence. Opposition, from whatever source it might come, Sir Ewart continued, must be overcome by understanding the reason for it, followed by full explanation and by the persistent education of all concerned, whether managers or workers. The effective initiation of work study, he suggested, required good management and provided a real test of its quality. Equally, the proper use of work study in an organisation helped to improve both the attitude and methods of managerial staff at every level.

Human Relations in Industry

In March, 1953, the Medical Research Council and the Department of Scientific and Industrial Research set up a joint committee on human relations in industry. The exact terms of reference given to the committee were " to examine current activities concerning the study of human relations in industry and to call attention to problems of special timeliness and promise on which research, including applied research and field study, might be undertaken or supported by the D.S.I.R., the Medical Research Council, or other bodies." This week the committee has published its first report.

At the outset, the report explains that, in anticipation of a heavy programme of work, it was decided to set up several sub-committees, each of which could follow a particular field of research interest. These sub-committees deal respectively with incentives, management organisation, promotion and training. The sub-committees have examined critically research proposals prior to consideration by the main committee. The report goes on to explain that when the committee was appointed it was the intention that a programme of research should be built up progressively over several years. The availability of Conditional Aid, financed by funds derived from the United States Economic Aid, has already enabled a research programme to be initiated on a scale that would not otherwise have been possible for some time to come. The committee is now, therefore, in the process of working out the basis for a systematic and comprehensive programme of work on the human relations problems of industry.

The report says that some seventy-eight applications for research, involving an expenditure of approximately £420,000, have been submitted for consideration, and twelve of them, representing an expenditure of £89,000, have so far been approved. One of these projects is concerned with the effect of incentive payment schemes on productivity, and is being undertaken by Birmingham University. The experience of factories which have introduced incentive payments will be assembled and analysed and account will be taken of trade union attitudes and experience. At Edinburgh University, two researches are to be undertaken. It has been found that in some firms there is friction between inspection and production departments which causes inefficiency. The work at Edinburgh is directed to finding out how the inspection process can best be organised to avoid this. The other project at Edinburgh is on the problem of adjustment to technological change and research on this subject is to be carried out with the co-operation of several Scottish firms which have recently begun to develop electronic equipment. Research into promotion and efficiency is being conducted by the Acton Society Trust. It will investigate the effect of promotion policy and practice on efficiency and morale in industry. Comparisons will be made between different promotion schemes in large-scale industry, and, the report adds, the effect on productivity of the reactions to promotion possibilities will be an important part of the study.

Research and Industry

A joint committee to investigate the possibility of speeding up the application to industry of the results of scientific research has been established by the Royal Society of Arts, the British Association, and the Nuffield Foundation. The Board of Trade has made a grant from " Conditional Aid " funds to enable the committee to begin research into the whole problem. An announcement which the committee has made this week says that for some years there has been a widespread feeling that while British fundamental research equals and frequently surpasses in excellence and achievement similar research in other countries, the translation of the results of research into industrial action has been too slow.

The new committee, it is stated, is well aware of the fact that much work is going on at the universities and in industry, all of which may lead to a reduction in the gap between research achievement and industrial application. Nevertheless, the committee's terms of reference, which have been accepted by the Board of Trade, are comprehensive. They include the making of a systematic and scientific appraisal of the whole problem, surveying the research already in hand elsewhere in order to see what further study is needed. The committee will also examine the factors which determine the speed of application of new scientific and technical knowledge in different industries and in different kinds of firms. In addition, it is stated, the committee proposes to collect evidence as to the effectiveness of measures already taken to speed up the application of science in industry, " or to remove hindrances to such application." Professor C. F. Carter is chairman of this committee and it is understood that some of its research work is already in progress.

Coal Production

On Thursday of last week, there was a further meeting between the National Coal Board and the executive committee of the National Union of Mineworkers to discuss coal output. A statement issued after the meeting said that the union executive assured the Board that it would do all in its power to help to secure an increase over last year's production, in accord with the pledge made during the wage negotiations at the beginning of this year.

The Divisional Coal Boards and the union's area executives are being enjoined forthwith to tackle the problem jointly at those pits where improvement in output is possible, recognising that basically the solution is to be found there. The Boards and the union area executives are to be asked to render a report within a month on what has been done, what is being done and what remains to be done at the pits to achieve the objective. These reports will be reviewed by a committee of six, which was set up in March last year, and which consists of the chairman and two other members of the National Coal Board, and the president, vice-president and secretary of the National Union of Mineworkers.

Notes and Memoranda

Air and Water

JUNE LAUNCHES OF NAVAL SHIPS.—We are informed by the Admiralty that twelve ships are to be launched for the Navy during June, including four coastal minesweepers, three inshore minesweepers, an anti-aircraft frigate, a fast replenishment tanker and three seaward defence boats.

LAUNCH OF LIGHT VESSEL.—Last month No. 1 Light Vessel Kish Bank was launched from the Noss Works of Philip and Son, Ltd. The ship, which is being built for the Commissioners of Irish Lights and was named "Gannet" at the launching ceremony, has a length overall of 136ft 5in by 25ft beam by 15ft depth moulded.

COASTAL MINESWEEPER H.M.S. "LABESTON."—Her Majesty's coastal minesweeper "Labeston" was launched on May 18th at the Belfast shipyard of Harland and Wolff, Ltd. The ship, which is of composite construction, is 152ft long by 28ft 9in beam and is powered by diesel engines built by Mirrlees, Bickerton and Day, Ltd.

RHINE BARGE CONVERSION.—The Rhine towing barge "Vulcaan 61" has been converted recently to a self-propelled vessel and renamed "Vulcaan 161." For propulsion purposes the barge, which has a length of 263ft by 29ft beam and a loaded draught of 8ft 4in, is powered by a Crossley Mark H.R.N., two-cycle, single-acting diesel engine having six cylinders of 267mm diameter by 343mm stroke and developing 500 b.h.p. at 340 r.p.m. The engine drives a four bladed cast iron propeller of 1·7m diameter by 0·96m pitch, housed in a semi-tunnel to give the barge a speed of 8·7 knots in deep water when loaded to a mean draught of 8ft 3in.

TONNAGE ALLOWANCE FOR MACHINERY SPACE.—July 1, 1954, has been appointed as the day when the Merchant Shipping Act, 1954, will come into operation. This Act amends the law relating to the allowance for propelling power space in merchant ships and provides that where the propelling power space measures 13 per cent of the gross tonnage the allowance is 32 per cent of the gross tonnage. This allowance will be proportionately reduced where the space measures less than 13 per cent, i.e. for a propelling power space of 12 per cent the allowance will be twelve-thirteenths of 32 per cent of the gross tonnage. For ships propelled by paddle wheels the corresponding percentages are 20 and 37.

LLOYD'S REGISTER OF SHIPPING.—Lloyd's Register of Shipping has issued its 1954 edition of *Rules and Regulations for the Construction and Classification of Steel Ships*. In the preface to the volume it is stated that the unification of the British Corporation Rules with the Lloyd's Register Rules is now complete and that the Classification and Periodical Survey Regulations now apply to both classes of ships. It is also announced that British Corporation class will no longer be granted unless the plans were approved before May 1, 1954. The volume, which has a comprehensive index, is divided into chapters marked alphabetically, the first three of which are concerned with regulations and the remaining eleven refer to construction rules. Chapter D deals with the construction of steel ships, including a special section for petroleum tankers, and there are associated tables with explanatory notes which give the scantlings required, geometrical properties of sections and welding and riveting information. Other chapters are concerned with pumping and piping and several deal with steam engines, internal combustion engines, gearing, boilers, spare gear, electric propelling machinery, electrical equipment and refrigerating machinery. A final chapter is devoted to quality and testing of materials and includes lists of proving establishments and manufacturers of steel, aluminium alloys and steel wire rope.

Miscellanea

TEST WELL AT GRANBY.—This month the D'Arcy Exploration Company expects to commence drilling a well at Granby, near Nottingham, in search of new sources of oil.

COPPER FOR BUSBARS.—We learn that the C.D.A. booklet, "Copper for Busbars," has been reprinted and can be obtained, gratis, from the Copper Development Association, Kendalls Hall, Radlett, Herts.

ADEN REFINERY.—It is announced by the Anglo-Iranian Oil Company, Ltd., that the company's 5,000,000 tons a year refinery, in which construction began in November, 1952, will come into operation in August next.

OIL PIPELINE.—An oil pipeline has been completed recently to connect the oil fields at Wasian and Mogoi, in Netherlands New Guinea, with the coast over 50 miles away. A 16in diameter pipe was laid from Wasian and Mogoi to Tembuni, where two 3000 tons capacity storage tanks and a pump house were built. From Tembuni an 8in diameter pipe, 37 miles long, was laid to Muturi Hill and two 22,000-ton capacity storage tanks built. For the last 10 miles to the marine terminal, on the River Muturi, a 24in diameter pipe was laid for gravity loading.

DIELECTRIC HEATING EQUIPMENT.—A twenty-three-page booklet dealing with the principles of dielectric heating equipment and with some practical applications has been published by Metropolitan-Vickers Electrical Company, Ltd., Trafford Park, Manchester, 17. The booklet outlines some of the uses of dielectric heating in medical therapy and in the woodworking, plastics, textiles and foodstuffs industries. The drying of foundry cores and of loose materials is mentioned and an inquiry sheet is included whereby prospective users can formulate their requirements.

CORRUGATED SHEETS.—The Northern Aluminium Company, Ltd., has published recently a booklet entitled "Noral Corrugated Sheets," which deals exclusively with this form of aluminium sheet in building construction. The advantages of using corrugated sheet are discussed and then technical data such as weight, loadings, coverage, is given for various forms of sheet. This is followed by information concerning accessories and fastenings and the booklet concludes with installation notes touching upon roof preparation, method of laying, fixing, bending, cutting and painting.

ALUMINIUM RESEARCH SCHOLARSHIP.—We are informed that the Institution of Structural Engineers has accepted an offer by the Aluminium Development Association of a Research Scholarship to the value of £400 a year for research on the application of aluminium alloy to structures. The scholarship will be awarded in alternate years for a two-year period and entries for the scholarship to be awarded this year close on July 15th. Forms of entry and further particulars can be obtained from the Secretary of the Institution of Structural Engineers, 11, Upper Belgrave Street, London, S.W.1.

INSTITUTION OF CIVIL ENGINEERS' AWARDS.—The Council of the Institution of Civil Engineers has announced the following awards for papers published in the *Proceedings* for 1953 :—Telford Premiums have been awarded to R. E. Gibson and Peter Lumb, jointly, for their paper "Numerical Solution of Some Problems in the Consolidation of Clay"; H. D. Morgan and C. K. Haswell, jointly, for their paper "The Driving and Testing of Piles"; D. B. Waters for his paper, "The Performance of Some Asphalt and Coated Macadam Mixing Plant," and T. P. O'Sullivan, for his paper, "Strengthening of Steel Structures Under Load." Trevithick Premiums have been awarded to Professor A. L. L. Baker, for his paper, "Further Research in Reinforced Concrete, and its Application to Ultimate Load Design," and to Jack Duvivier, for his paper, "Some Recent Works on the East Coast, 1942–52."

GASIFICATION OF SOLID FUEL.—The increased demand in Europe for gas either as town gas, producer gas or synthesis gas for the production of oils and chemicals, has led to the consideration of the use of low-grade or small-sized coals not normally used for gas making. A special working party of the O.E.E.C. Committee for the Co-operation of Scientific Research was set up to ascertain what work had been done on the gasification of solid fuels in the form of fines, particularly by methods which could be used under pressure. A report has been drafted by experts from ten European countries and published under the title of "Increased Thermal Efficiency of Solid Fuel Through Gasification." This report outlines the thermal and chemical basis of the different gasification processes, and gives also a detailed description and assessment of each process with special emphasis on the possibility of co-operative research among member countries. Copies of this report may be obtained from H.M. Stationery Office at a price of 8s. 6d. Comments on the report and requests for further information should be addressed to Mr. R. Ashton, Intelligence Division, Department of Scientific and Industrial Research, 15, Regent Street, London, S.W.1.

IRON AND STEEL PRICES.—The Iron and Steel Board has announced price increases in a number of iron and steel products. These increases average just under 2 per cent and range in the main from 15s. a ton for pig iron and heavy steel products down to 2s. 6d. a ton on the lighter products; there are higher prices for a few products, and no change has been made in the prices of others. At the time of the increase in rail freight charges on March 1st the Board stated that no increases in steel prices were then being made on account of rail charges, but that all costs would be kept under review and such adjustments in prices as might be necessary would be made from time to time. The present advances in iron and steel prices have been made necessary by the increase in coal and coke prices which came into force on May 3rd and by recent wage increases. A new tinplate schedule has been introduced to reflect the economies in the production by the strip mills of bulk quantities of standard products. The result is a slight reduction in the average prices to the consumer of the strip mill tinplate, which now represents about two-thirds of the total production. While hand mill prices have in general been increased the new price schedule will still leave the hand mill product cheaper than that of the strip mill for small quantities and special requirements. The price changes came into effect on May 31st.

Contracts

THOS. STOREY (ENGINEERS), Ltd., Stockport, has received an order from the Canadian Government for Bailey pontoons to the value of £168,000.

THE BURNTISLAND SHIPBUILDING COMPANY, Ltd., has received from William Cory and Son, Ltd., an order to build a self-trimming collier of 4600 tons deadweight. The ship will have a length between perpendiculars of 320ft, a breadth of 46ft, a depth moulded of 22ft 4in, a load draught of 20ft 2in and will be propelled by a six cylinder Clark-Sulzer diesel engine of 1300 b.h.p.

THE GENERAL ELECTRIC COMPANY, Ltd., announces that its Fraser and Chalmers Engineering Works, Erith, Kent, has received an order from the New Consolidated Gold Fields, Ltd., for a four-rope Koepe winder. The winder will raise gold-bearing ores for the West Driefontein Gold Mining Company, Ltd. It is designed for a skip load of 14 short tons, the skip travelling from a depth of 5460ft. The drum carrying the four ropes will be 17ft 6in in diameter and the total suspended load on the 26in diameter main bearings will be of the order of 120 tons. The maximum rope speed is designed at 3000ft per minute and the total winding cycle 136 seconds. The total value of the contract is about £130,000.

THE BRITISH TRANSPORT COMMISSION has placed orders with The English Electric Company, Ltd., for 170 sets of equipment for 350 h.p. diesel-electric shunting locomotives for British Railways, seventy-eight of them to be delivered next year and the remaining ninety-two in 1956. These locomotives will be built in British Railways workshops in 1955 and 1956.

Personal and Business

SIR GUY NOTT-BOWER, K.B.E., has retired from the position of Director of Public Relations, National Coal Board.

NU-WAY HEATING PLANTS, Ltd., Droitwich, states that Mr. C. V. Miller, sales manager, has been appointed a director.

WILLIAM JONES, Ltd., has moved its offices to Adam House, 1, Fitzroy Square, London, W.1 (telephone, Euston 7871).

THE ATLAS DIESEL COMPANY, Ltd., Wembley, has moved its Midlands branch to 1, Mary Street, Walsall, Staffs (telephone, Walsall 3510).

LONDON TRANSPORT has announced the retirement of Mr. H. S. Chapman from the office of treasurer. His successor is Mr. H. W. Aldridge.

HIGGS MOTORS, Ltd., Witton, announces the appointment of Mr. G. L. Hankey as technical sales representative in the South Wales area.

VICKERS-ARMSTRONGS, Ltd., has appointed Richardson Agencies, Ltd., 454, King Street West, Toronto, 1, as sole agent in Canada for the sale of strip-wound pressure vessels.

MR. R. H. VARNOM has been appointed sales manager of the electrical wholesaling division of the Donovan Electrical Company, Ltd., 70–82, Granville Street, Birmingham, 1.

MR. G. B. G. POTTER, M.I.Mech.E., managing director of Kelvin and Hughes, Ltd., has been appointed to the board of the parent company, S. Smith and Sons (England), Ltd.

MR. VICTOR C. H. CREER, a director of the British Thomson-Houston Company, Ltd., has been elected chairman of the council of the Electric Lamp Manufacturers' Association.

MR. J. W. HENDERSON, M.I.C.E., is relinquishing his post as chief engineer of the Hemel Hempstead Development Corporation to become chief executive officer of the Lagos Executive Development Board.

F. HAWORTH (A.R.C.), Ltd., Ramsbottom, Lancs, has opened a London office at 40, Buckingham Palace Road, S.W.1 (telephone, Tate Gallery 3861). Mr. D. P. Hulbert, a director of the company, is in charge.

MR. G. M. SHEPLEY has been appointed secretary of Brook Motors, Ltd., Huddersfield, in succession to Mr. W. Mills, who has resigned for health reasons. Mr. Mills continues to serve on the board of the company.

NORTHERN ALUMINIUM COMPANY, Ltd., announces the retirement of Mr. R. G. Hull, manager of the Manchester sales office. Mr. Hull, who has been with the company for twenty-seven years, is succeeded by Mr. D. A. Corbett-Thompson.

MR. L. A. FERNEY, M.I.Mech.E., has resumed his industrial consulting practice, in which he is associated with Mr. D. J. Desmond, M.I.E.E., and Mr. A. J. Lucking, A.C.G.I., at 93, Westbourne Terrace, London, W.2 (telephone, Paddington 9604).

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Ltd., announces that Mr. A. H. Lawson has joined the staff at Trafford Park as sales engineer. This follows the transfer to Metropolitan-Vickers of the resistance welding business of British Insulated Callender's Cables, Ltd.

MR. KEITH N. HILLAS, managing director of W. N. Hillas and Co., Ltd., Hull, was elected chairman of the Timber Development Association at the annual general meeting of the Timber Development Association held on May 18th. The retiring chairman was Mr. G. B. Crow, managing director of Beves and Co., Ltd., Shoreham, who held the office for two years.

WESTINGHOUSE BRAKE AND SIGNAL COMPANY, Ltd., states that, in conjunction with Bellamy and Lambie (Pty.), Ltd., Johannesburg, a new company has been formed under the title of Westinghouse Brake and Signal Company S.A. (Pty.), Ltd. The new company will manufacture certain items of railway, road and mining equipment and provide test, service and spares facilities.

THE CEMENT AND CONCRETE ASSOCIATION, 52, Grosvenor Gardens, London, S.W.1, has opened a northern office in Manchester. The address of the new office is 11, Albert Square, Manchester, 2 (telephone, Blackfriars 2525/6), and its manager is Mr. B. Boothby. Mr. Boothby's former duties as press and public relations officer of the Association's London office have now been taken over by Mr. P. J. Witt.

THE FAIREY AVIATION COMPANY, Ltd., announces the following changes on the board of its subsidiary, Air Survey Company, Ltd.:—Group Captain F. C. V. Laws has succeeded Mr. C. H. Chichester Smith as chairman, and Colonel R. T. L. Rogers becomes managing director; Mr. G. W. Hall, a director of the parent company, has been appointed to the board of the subsidiary, and Mr. Chichester Smith is concentrating on the parent company's weapon division.

British Patent Specifications

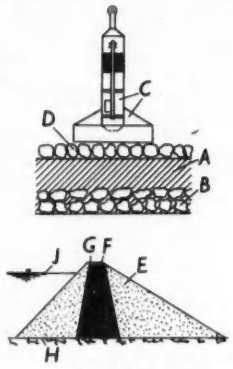
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

CIVIL ENGINEERING

708,288. July 26, 1951.—CONSTRUCTION OF WATERTIGHT STRUCTURES, Wilhelm Degen, 89, Zeppelinallee, Frankfurt-am-Main, Germany.

The invention concerns improvements relating to the construction of watertight structures for dams, canals, &c., to give better bonding and to prevent settlement. In the upper drawing a cross section of a portion of a watertight bottom for a canal under construction is shown, with a tamper operating on a



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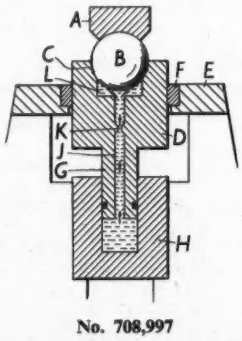
layer of stone; and the lower view shows a cross section of a finished dam with a core made according to the invention. *A* is a tipped layer of clay constituting the binding material into which stones *B* have been worked by the rammer or vibrator *C*. A further layer of coarse stone *D* is then placed on the top of the layer *A* for working into the binding material by the rammer. The repetition of tipping and shaking results in a core of maximum density. In the lower view a dam *E* has a core *F* consisting of binding material, into which has been worked the stone *G*, layer by layer, *H* is the sill and *J* the dammed water level. The invention can also be used with advantage for making the walls or embankments of ship and irrigation canals, dams, &c., where there is danger of losses by seepage due to the bottom not being sufficiently watertight. The provision of an artificial bottom of binding material reinforced with a stone core in the manner described prevents these losses in an efficient and economical manner. The usual clays can be employed as binding materials; but other materials, having suitable properties, such as a fine-grained earthy substance can be used, with or without the addition of natural or artificial binders.—*May* 5, 1954.

BEARINGS AND SUPPORTS

708,997. May 23, 1952.—HYDRAULIC THRUST BEARINGS, The English Electric Company, Ltd., Queen's House, 28, Kingsway, London, W.C.2. (*Inventor: George Fritz Werner Adler.*)

According to the invention, the hydraulic pressure required for the bearing is generated by the weight of the runner itself, by supporting the seat of the ball on a hydraulic ram acting in a cylinder, the interior of which is connected to the seat below the ball. By



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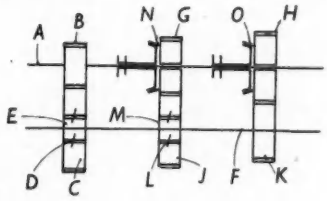
appropriately dimensioning the seat and the diameter of the cylinder the runner register assembly and the runner placed on it are supported by the hydraulic pressure generated, which varies as the weight of the runner. Referring to the drawing, the load *A*, such as a runner register assembly, rests on a ball *B* forming a self-aligning and self-centring thrust bearing. This ball rests on a concave seating *C* which accurately fits the ball. This seating is provided in the bearing body *D*, which is slidably guided in the supporting structure *E* by means of a guide ring *F* and restrained from rotation by a key. At its bottom the body carries a hydraulic ram *G*, which is slidable in a hydraulic cylinder *H* fitted into the supporting structure. This ram has a central bore *J* with a restricted orifice *K* arranged in it and leading to a recess *L* under the ball. In operation, the load, such as a hydraulic turbine runner to be balanced, is placed on to the runner register assembly *A*. Its weight is transmitted through the ball *B* on to the seating *C*, which is integral with the ram. Thereby the oil enclosed in the cylinder *H* is put under high pressure and tends to flow through the bore *J* and restricted orifice *K* into the recess *L* under the ball. The relative cross section areas of the cylinder and of the recess are selected in such a way that the pressure under the ball is just sufficient to lift it from its seat and to make it float on a very fine layer of lubricant, which slowly seeps away past the ball. The leakage flow allowed between the ball and the seating can be throttled and controlled by the restricted orifice or other flow restricting device. This leakage will result in a very slow sinking of the system, which does not interfere with the balancing operation of the runner. Where the sinking of the ram and its load is undesirable, additional hydraulic pressure can be supplied, and this arrangement is also described in the specification.—*May* 12, 1954.

POWER TRANSMISSION

708,725. March 19, 1951.—HYDRO-MECHANICAL TRANSMISSION FOR VEHICLES, Regie Nationale des Usines Renault, 8-10, Avenue Emile Zola, Billancourt (Seine), France.

The invention relates to road or rail automotive vehicles driven by one or more gas turbines, in which the transmission from the turbine or turbines to the



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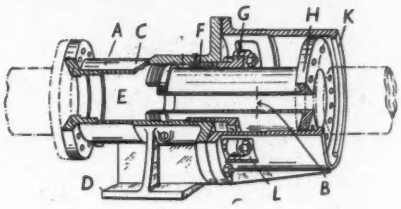
driving axles is hydromechanical. The change-speed gear is preferably of the continuous traction type and the drive on the wheels is not interrupted during gear changing. In the drawing the primary shaft *A* carries a pinion *B* driving a gear wheel *C*, which drives, through a free wheel *D*, a hub *E* keyed on a secondary shaft *F*. Similarly, loose pinions *G* and *H* of the second and third speeds mesh with gear wheels *J* and *K*. The wheel *J* drives, through a free wheel *L*, a hub *M* keyed on the secondary shaft *F*. The wheel *K* corresponding to the highest speeds is keyed, without a free wheel, on the shaft *F*. The wheels *G* and *H* can be driven at will by the shaft *A* by means of clutches *N* and *O*. The arrangement thus described starts in first speed as soon as the turbine is operative. In order to pass to second speed it is sufficient to engage the clutch *N*, whereupon the free wheel *D* functions. In order to pass to third speed the clutch *O* is engaged, without disengaging the clutch *N*. The two free wheels *D* and *L* then come into operation. In order to engage lower gears the clutches *O* and *N* are disengaged in succession. The arrangement described above is given purely by way of example. Use may be made of any arrangement comprising any number of speeds and giving the same result, in particular by means of planet gear arrangements.—*May* 12, 1954.

TUBE AND PIPE COUPLINGS

709,068. July 12, 1951.—EXPANSION JOINTS FOR PIPES, Foster Brothers, Ltd., Lea Brook Tube Works, Wednesbury, Staffordshire. (*Inventor: Humphrey Frederick Foster.*)

The object of the invention is to provide an improved expansion joint for a pipeline capable of operating under fluid conditions where temperature and pressure may reach 800 deg. Fah. and 400 lb per square inch. In the drawing an expansion joint *A* is interposed between and fastened to coaxial pipes. The joint comprises coaxial inner and outer tubular members *B* and *C* of which the inner member is telescopically movable in the outer member supported from a foot *D*. The inner member *B* works piston like in the bore of the outer member *C* and the head is provided with piston rings *E*. A stuffing-box *F* in a groove behind the piston head is backed up by a gland *G* which is bolted to a flange of the outer member and is adjustable from the outer face of the flange. The end of the inner member *B* remote from the piston head is provided with an annular flange *H* sliding in the bore of a tubular extension of the outer member *C*. The piston head of the inner member is axially supported throughout its telescopic movement



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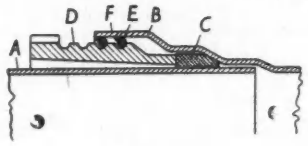
in the outer member *C*, and an inturned rim *K* on the extension forms a stop for limiting its movement. The extension is provided with peripheral openings for access to the gland and stuffing-box. The outer member *C* is provided with a relief valve *L*, by which the steam or condensate can be taken away.—*May* 12, 1954.

708,883. May 16, 1952.—PIPE JOINTS, Westdeutsche Mannesmannröhren Aktiengesellschaft, 125, Ulmenstrasse, Düsseldorf, Germany.

As shown in the drawing, the spigot end *A* of one tube and the stepped socket portion *B* of a second tube have between them a packing *C* which abuts a



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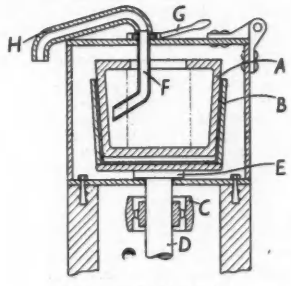
hollow conical surface of the socket portion *B* and is forced against the conical surface by a gland *D* screwed into the socket. A helically wound wire *E* welded to the inside of the end *F* of the socket portion acts as the thread complementary to the external thread of the gland *D*.—*May* 12, 1954.

METALLURGY

708,782. May 19, 1952.—CASTING WITH A ROTATING CRUCIBLE, Georg Pemetzrieder, 57, Thuyring Berlin-Tempelhof, Germany.

The invention provides an apparatus comprising a melting pot or crucible and a centrifuging apparatus



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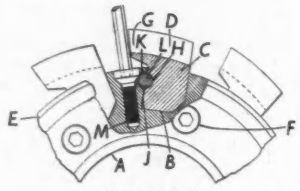
having a container to receive the heated pot and rotate it at the speed required to effect the centrifuging of the molten metal in the pot. In the drawing the melting pot or crucible containing the metal is shown at *A*. A centrifugal container *B*, receiving the melting pot is driven by the belt pulley *C* fastened on the shaft *D* provided with a flange *E* to which the container is fastened. A delivery pipe *F* within the fixed protective housing may be turned by means of a handle *G* so that its open end extends into the liquid metal ring formed during the rotation of the container and indicated in the drawing by dot and dash lines. A stationary pipe *H* serves for transmitting the jet of liquid metal to moulds. During the insertion or removal of the melting pot the delivery pipe must be turned into the neutral position.—*May* 12, 1954.

TOOLS AND WORKSHOP APPLIANCES

709,064. December 27, 1950.—HOBBING TOOLS, The Fellows Gear Shaper Company, 78, River Street, Springfield, Vermont, U.S.A. (*Inventor: Joseph Riley.*)

The invention relates to hobbing tools having a body portion formed at its periphery with longitudinal slots in which cutting elements are secured. As the drawing clearly shows, the hobbing tool comprises

a body portion *A* with angularly spaced longitudinal slots *B* to receive cutting elements or blades *C* having a series of cutting teeth *D*. End plates *E* are secured on the body by screws *F* and accurately locate the axial position of the blades. The blades have an



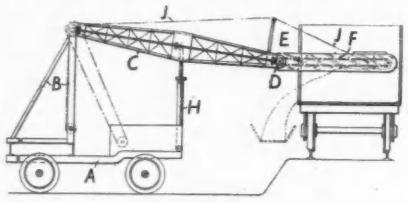
No. 709,064

overhung portion *G* at the cutting end of the teeth providing ample material for a large number of sharpening operations. The blades are formed with a semi-circular groove *H* in their forward face *J* and this groove is aligned with a semi-circular groove *K* in the adjoining face of the slot *B*. The aligned grooves, which accommodate a pin *L*, may be removable or secured to the cutting blade. Between each pair of slots *B* is a number (three) of threaded holes *M* which accommodate blade locking screws having a conical surface which engages the pin *L*.—*May* 12, 1954.

RAILWAY ENGINEERING

708,731. May 24, 1951.—UNLOADING COAL OR OTHER MATERIALS FROM RAILWAY TRUCKS, Norman Francis Matthews, 22, Westgarth Street, Northcote, Victoria, Australia.

As shown in the drawing, the apparatus comprises a motor vehicle chassis *A* having mounted on it a framework *B* to which the jib *C* is pivoted. The jib overhangs the chassis and its forward end pivotally supports at *D* the dredger member *E*. The dredger member has endless chains *F* carrying transverse blades or scrapers. The chains are driven from



No. 708,731

the power unit of the chassis as shown. Lifting means, such as a hydraulic ram *H*, are provided for raising and lowering the jib, or it can also be raised and lowered by means of a cable *J* connected to the forward end of the dredger member. In use, the apparatus is manœuvred so that the dredger *E* extends through the door opening of the railway truck as shown. The dredger member is then operated so that its scrapers draw the coal or material through the door.—*May* 12, 1954.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

LETTER SYMBOLS, SIGNS AND ABBREVIATIONS. PART I : GENERAL

No. 1991 : 1954. Price 6s. When it was decided to revise two well-established and partly overlapping British Standards, viz., B.S. 560 : 1934, "Engineering Symbols and Abbreviations"; and B.S. 813 : 1938, "Chemical Symbols and Abbreviations," it was thought desirable to take this opportunity of combining them so as to remove unnecessary conflict and pave the way to the development of a consistent system of signs, symbols and abbreviations for the whole field.

As B.S. 560 covered such specialised subjects as "locomotive classification," "naval architecture," and "hydraulics and water engineering," the B.S.I. Committee entrusted with this work decided that, in the first instance attention should be focused on the more fundamental quantities of common concern to all branches of pure and applied science, on conventions relating to their use, and on abbreviations for relevant words, especially the names of unit. This new specification, B.S. 1991 : 1954—Part I : General, is the outcome of this decision; and it will be left to groups of experts in specialised fields to build in various directions on the foundations thus laid.

It is recognised that the attainment of a reasonable measure of agreement will entail the abandonment of a few practices that are well established in certain fields of work, but it is believed that the sacrifice is worth making. Departures from well-established usages are recommended, however, only where they are considered to be of serious importance.

Besides providing recommendations for a wide, but by no means complete, range of quantities, the standard is intended to give guidance towards the development of a general system. It urges that the general principles put forward should be accepted and followed rather than that there should be rigid adherence in all instances to recommendations on the use of individual symbols or abbreviations. In particular there should be no departure from the consistent use of italic (sloping) type for symbols for physical quantities (whether the letters are capitals or lower case), and of roman (upright) type for most other purposes, such as abbreviations for words, including the names of units. In the present revision and combination of the more fundamental features of the two British Standards, full account has been taken of the recommendations of the Royal Society Symbols Committee and of the reports issued from time to time by such international bodies as the International Electrotechnical Commission, the International Union of Pure and Applied Chemistry, and the International Union of Pure and Applied Physics.

DIMENSIONS OF THREE-PHASE ELECTRIC MOTORS

No. 2083 : 1954. Price 2s. 6d.—The dimensions of fractional horsepower motors were laid down in B.S. 2048 : 1953. A further step towards dimensional standardisation of electric motors in the United Kingdom is taken in B.S. 2083 : 1954. It establishes nine frame sizes for squirrel-cage, totally enclosed fan-cooled foot-mounted motors intended for industrial purposes and having a maximum continuous rating and is applicable to 50 c/s motors at voltages not greater than 650V and covers motors of 1 h.p. to 20 h.p. at 1500 r.p.m. (synchronous speed). With the exception of the 1 h.p., four-pole motor, the dimensions specified are similar to those given in the American N.E.M.A. Standard MG 1-1949, but for a given frame size the horsepower outputs have been increased to fall into line with practice in this country and shaft dimensions have been enlarged accordingly.

It is recognised that there will be a considerable transition period before all motors can be supplied exactly in accordance with this standard, and mutual agreement between contracting parties as to the extent of its application may initially be necessary.

Launches and Trial Trips

REGENT ROYAL, oil tanker; built by the Blythswood Shipbuilding Company, Ltd., for Trinidad Leaseholds, Ltd.; length between perpendiculars 487ft, breadth 65ft 6in, depth moulded 35ft 4in, deadweight 14,400 tons; twelve passengers; twenty-four cargo oil tanks, two pump rooms, four cargo oil pumps of 1500 tons per hour total capacity, one 150 tons per hour pump for detergent spirit; Rowan-Doxford two-stroke, oil engine, four cylinders 670mm diameter by 2320mm combined stroke, 4500 b.h.p., two single ended multitubular boilers; trial speed 14·3 knots.—Trial, May 18th.

SYLVAN ARROW, oil tanker; built by the Netherlands Dock and Shipbuilding Company, Amsterdam, for Rispond Tankers, Ltd.; length between perpendiculars 192·92m, breadth moulded 26·21m, depth 13·72m, draught 10·36m, deadweight 31,000 tons; thirty cargo oil tanks; two 500kW turbine-driven generators; one set of N.D.S.M.-Parsons double reduction geared turbines taking steam at 615 lb per square inch and 788 deg. Fah.—Trial speed 16·9 knots.—Launch, May 22nd.

SIR DAVID II, steam collier; built by Hall Russell and Co., Ltd., for the North Thames Gas Board; length between perpendiculars 320ft, breadth moulded 46ft, depth moulded 22ft 4in/27ft 10in, deadweight 4600 tons on 20ft draught; four holds, steam deck machinery; "North Eastern Reheat" direct-acting, triple expansion steam engine, 1275 i.h.p., steam supplied at 220 lb per square inch by two oil-fired cylindrical boilers.—Trial, May 24th.

SWIFTPOOL, cargo liner; built by The Caledon Shipbuilding and Engineering Company, Ltd., for Sir R. Ropner and Co. (Management), Ltd.; length overall 485ft, breadth moulded 63ft 3in, depth to shelter deck 40ft 9in, gross tonnage 6725, deadweight 9870 tons on 27ft 3¼in draught; twelve passengers; six cargo holds, four 10-ton and fourteen 5-ton derricks, electric deck machinery; three 200kW diesel-driven generators; Stephen-Doxford oil engine, six cylinders 725mm diameter by 2250mm combined stroke.—Trial, May 24th.

ROLLO, cargo ship; built by Henry Robb, Ltd., for Ellerman's Wilson Line, Ltd.; length between perpendiculars 290ft, breadth moulded 48ft 6in, depth moulded to upper deck 27ft, deadweight 2400 tons on 17ft 9in mean draught, service speed 13 knots; twelve passengers; four cargo holds, steam deck machinery; two 60kW steam-driven generators; triple expansion steam engine, cylinder diameters 20in, 34in and 56in by 39in stroke, and Bauer-Wach exhaust steam turbine, steam supplied by two cylindrical multitubular boilers at 225 lb per square inch.—Launch, June 1st.

Catalogues

GEO. W. KING, Ltd., Stevenage, Herts.—Leaflet on overhead runways.

ALFRED HERBERT, Ltd., Coventry.—New booklet on Herbert ground thread taps.

JOSHUA HEAP AND CO., Ltd., Ashton-under-Lyne.—Folder describing threading machines.

THE BERYLLIUM CORPORATION, Reading, Pennsylvania.—Leaflet describing beryllium nickel.

FOSTER INSTRUMENT COMPANY, Ltd., Letchworth, Herts.—Book No. 112, "Foster Practical Pyrometers."

JAMES NEILL AND CO. (SHEFFIELD), Ltd., Napier Street, Sheffield, 11.—Booklet, "How to Use Hacksaw Blades."

TRANSFORMERS (WATFORD), Ltd., Sandown Road, Watford, Herts.—Catalogue describing T.W. transformers.

ANSON INDUSTRIES, Church Street, Castleford, Yorks.—Leaflet entitled "Shell Mouldings Anson the Answer."

LENNOX MOTOR COMPANY, Ltd., Grove Road, South Southsea.—Leaflet describing the Lennox-Lomax auto unit.

KODAK, Ltd., Wealdstone, Harrow, Middlesex.—Leaflet describing the Kodak Model 56 X-ray processing unit.

DOMINION ENGINEERING COMPANY, Ltd., Winnipeg, Canada.—Bulletin No. 368–53, describing Dominion gear units.

WAILES DOVE BITUMASTIC, Ltd., Hebburn, Co. Durham.—Technical Leaflet No. 14, describing Bituplastic No. 28.

SMITH METERS, Ltd., Rowan Road, Streatham Vale, London, S.W.16.—Booklet on Smith precision indicator gauges.

TAYLOR AND CHALLEN, Ltd., Derwent Works, Birmingham, 19.—Catalogue, Section 8, describing cartridge machinery.

ADDY PRODUCTS, Ltd., Belvedere Works, Northam, Southampton.—Illustrated catalogue of Addy standard jig parts.

AERO HEAT TREATMENTS, Ltd., Sarehole Road, Hall Green, Birmingham, 28.—Leaflet describing the companies' services.

STANDARD TELEPHONES AND CABLES, Ltd., Telephone Division, Oakleigh Road, New Southgate, London, N.11.—Booklet D/Rc 26, "Centralised Supervisory Control."

B. ELLIOTT AND CO., Ltd., Victoria Works, Willesden, London, N.W.10.—Four leaflets describing additions to the range of milling machines manufactured by the company.

NORMAND ELECTRICAL COMPANY, Ltd., North Street, Clapham Common, London, S.W.4.—List No. 541, giving details of Neco Buxton certified flameproof motors and geared motors.

AUSTIN CROMPTON-PARKINSON ELECTRIC VEHICLES, Ltd., 95–99, Ladbroke Grove, London, W.11.—Leaflet describing the latest addition to the M.E. range of electric vehicles, the "E.D. 25."

MONOMETER MANUFACTURING COMPANY, Ltd., "Savoy House," 115–116, Strand, London, W.C.2.—Brochure of "Monometer" metal melting furnaces, which can be arranged for oil or gas-firing.

GENERAL ELECTRIC COMPANY, Ltd., Magnet House, Kingsway, London, W.C.2.—Three bulletins describing: (1) G.E.C. M.W. switch fuses; (2) G.E.C. M.W. fuse switches; and (3) G.E.C. M.W. switchboard.

A. REYROLLE AND CO., Ltd., Hebburn, Co. Durham.—Leaflet 10MS 417, "Installation and Maintenance Recommendations for Oil-filled, Post-type Current Transformers, 88kV to 275kV"; and Pamphlet 1224, "The Relay Handbook."

IMPERIAL CHEMICAL INDUSTRIES, Ltd., Imperial Chemical House, Millbank, London, S.W.1.—Booklets, "Integron Low Fin Tubing for Use in Freon 12 Water Cooled Condensers," and "Integron High Fin and Low Fin Tubing."

ELECTRO DYNAMIC CONSTRUCTION COMPANY, Ltd., St. Mary Cray, Kent.—List No. 6 A.A., "Electro-Dynamic, Self-Regulating Alternators." List No. 17 M.C., "Electro-Dynamic Magnetic Couplings." List No. 18 T.M., "Electro-Dynamic Battery Traction Motors."

BRITISH MONORAIL, Ltd., Wren Works, Chadderton, Lancashire.—Publication BMH2, "Overhead Handling Equipment," and a folio of engineered applications or case studies relating to the overhead handling equipment made by the company in association with the American Monorail Company.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

INSTITUTE OF NAVIGATION

To-day, June 4th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Exploring the Ocean Bed," Bruno Vailati, 8.15 p.m.

Fri., June 18th.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Methods of Training in Navigation," Discussion introduced by W. L. S. Harrison, 5 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., June 8th.—Great George Street, Westminster, London, S.W.1, Annual General Meeting, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Fri., June 11th.—MEASUREMENTS SECTION: Summer Visit to Rugby and Bourneville.

Fri., June 18th.—EDUCATION DISCUSSION CIRCLE: Engineering Laboratory, The Polytechnic, Battersea, Exhibition of Apparatus, 6 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

Mon., June 14th.—N.E. BRANCH: Stephenson Building, King's College, University of Durham, "The Place of Sir Charles Parsons in the History of Mechanical Engineering," Aubrey Burstall, 6 p.m.

Tues., Wed. and Fri., June 15th, 16th and 18th.—Stephenson Building, King's College, University of Durham, Sir Charles Parsons Centenary Exhibition, 7 p.m. to 8.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

Mon., June 21st.—EXTRAORDINARY GENERAL MEETING: Towns end House, Greycoat Place, London, S.W.1, 6 p.m.

SOCIETY OF CHEMICAL INDUSTRY

To-day, June 4th.—CORROSION GROUP: Joint Confefence with the Association Belge pour l'Etude, l'Essai et l'Emploi des Materiaux (A.B.E.M.), Brussels.

WOMEN'S ENGINEERING SOCIETY

Wed., June 16th.—LONDON BRANCH: 35, Grosvenor Place, London, S.W.1, Annual General Meeting, 7 p.m.